POWER

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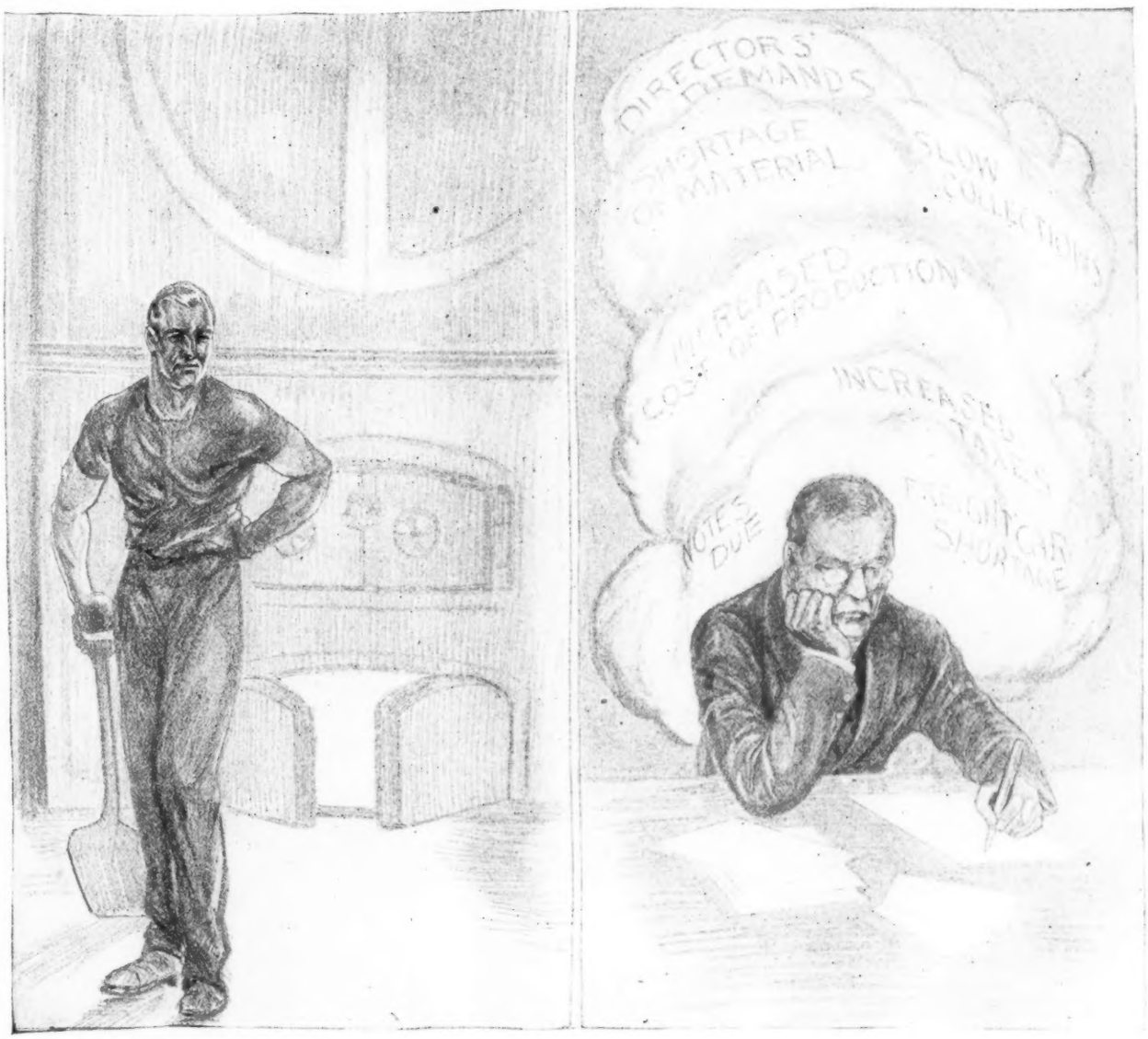
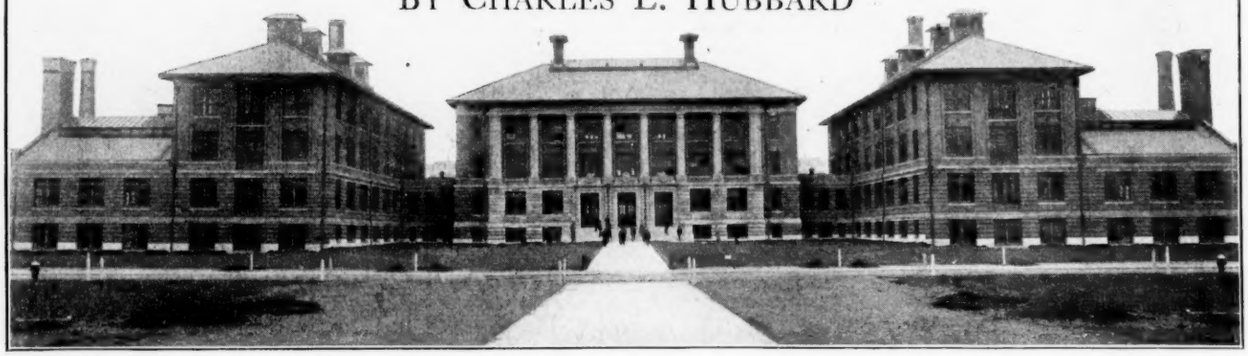
Would You Change Places?



And Each Thinks the Other Has a Snap

Wentworth Institute Power Plant Course

BY CHARLES L. HUBBARD



SYNOPSIS—Wentworth Institute, the first school of its class, offers a full-time day course devoted to power-plant operation. Of the 40 hours per week, 22 will be given to actual work in the shop and power-plant laboratories; the other 18 hours will be devoted to the theoretical side in the class and drafting rooms. Various kinds of power-plant apparatus are supplied for the practical work of the student, and facilities for testing are at hand.

An important development in the work at the Wentworth Institute, Boston, Mass., is a new course in power-plant operation to be opened this coming fall. Although some instruction along this line, as one subject among many, has previously been given to men in the two-year courses in "Machine Construction and Tool Design" and "Electrical Construction and Operation" (ten hours per week during the second year), and although such instruction has also been included in the list of evening courses, the proposed step marks the beginning of the development of a course in which power-plant operation is the major interest and in which instruction along other lines is secondary or supplementary.

This, so far as the writer knows, is the first school of its class to offer a full-time day course devoted entirely to this important branch of engineering. It is, of course, to fit young men to become operating engineers in the same thorough fashion as the large technical schools fit men to become designing and testing engineers. Experienced engineers with first-class licenses will not be turned out, but young men so thoroughly grounded in both the practical and theoretical sides of their chosen work that they will be enabled to become such in a short time after leaving the school.

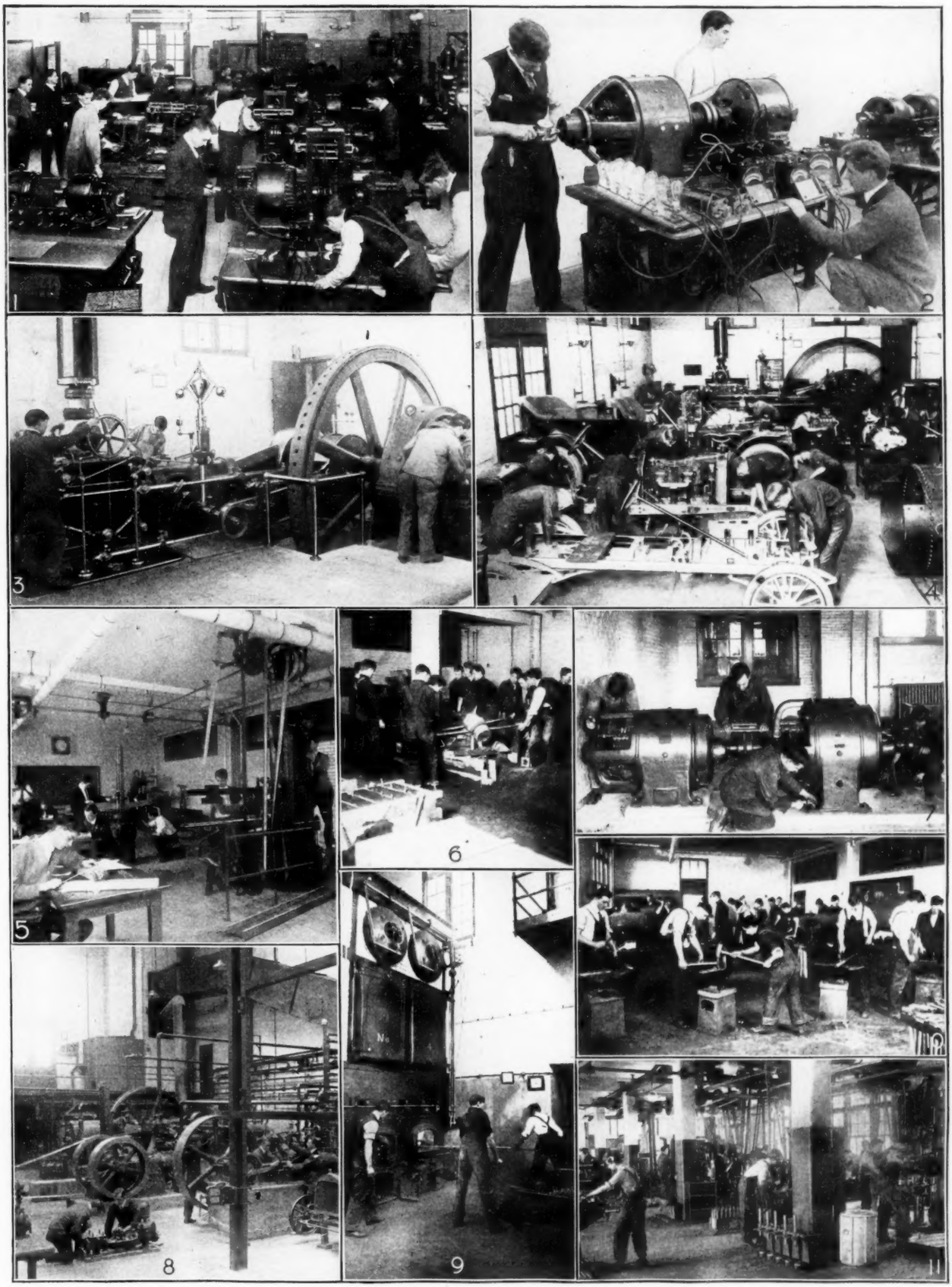
Under the Massachusetts laws from two to three years are required to secure a first-class engineer's license after obtaining one as a fireman, provided the applicant is able to pass his examinations as fast as he is allowed to take them. As a matter of fact, the average age of men receiving first-class engineers' licenses in that state is 35 years. That is, twelve to fifteen years are actually required to attain what should be possible in three to five if the man had the necessary theoretical and practical training at the start.

Men graduated from this course are supposed and required to have, in addition to their vocational knowledge, a willingness to start at the bottom and to do the rough and dirty work of the plant at the beginning. If a young man manifests anything of the "kid glove" quality, steps are taken to overcome it in such a rational and unobtrusive manner that if he has the right stuff in his make-up, this objectionable feature is eliminated quietly, and practically without his knowledge. No student is allowed to feel above his work, and any such feeling is forced out by instilling a genuine interest and enthusiasm. This quality is especially necessary in power-plant operation, where the engineer must get down to a personal oversight of the smallest details and not be afraid to use his own hands when occasion requires.

This training of the mental attitude has been carried out so well in connection with the work of other courses previously established that there is no doubt of its being equally successful when applied to the new course.

Another important feature, which has been given careful attention since the opening of the school and which will be continued in the new development, is the discrimination exercised in selecting the right kind of students for the different courses. Much skill is required in assigning the men along the lines of work to which they are best adapted. Examinations cannot be used, in the ordinary sense of the word, to determine the fitness of the applicants for the various trades, for it often happens that a person who has not even finished the eighth grade in the public school proves himself superior to others who have attended school for a longer time. An effort is made to analyze each trade and to determine the qualities of mind and of character that are especially needed for success in each, also the physical qualities required.

No infallible system has been invented for determining which men or boys have the needed qualities, but care is taken, nevertheless, to determine this. Each applicant is required to have one and sometimes two or three interviews with the principal of the school. After this similar interviews are had with the several heads of departments. In these interviews the eye, voice, manner, physique, previous experience and the extent to which previous experience has been taken advantage of are all included in the general summing up of the applicant's



FIGS. 1 TO 11. VIEWS OF THE WENTWORTH INSTITUTE LABORATORIES

Fig. 1—Electric-motor laboratory. Fig. 2—Students testing a motor-generator set. Fig. 3—Main generating set. Fig. 4—Gas-engine laboratory. Fig. 5—Testing strength of materials. Fig. 6—View of foundry. Fig. 7—Students installing a motor-generator set. Fig. 8—General view in steam laboratory. Fig. 9—Partial view of the boiler room. Fig. 10—Forge shop. Fig. 11—Machine shop

qualifications; but perhaps the greatest weight is given to the intensity of interest in the calling for which the applicant seeks training, together with the evidence of courage in facing and overcoming obstacles.

After such interviews those who do not show the necessary fitness for the particular kind of work they wish to undertake are advised to try something else. When they do show promise of success, they are accepted for a period of trial only. In selecting men for the new course in power-plant operation, the same care will be exercised in choosing only such as give promise of the necessary qualifications for this particular line of work.

Forty hours per week will be required, 22 of these being given to actual work in the shops and power-plant laboratories while the other 18 will be devoted to the theoretical side in the class and drafting rooms. In the older technical schools the theoretical side is given the preference, but here the practical side will be given the major proportion of time, it being supplemented by sufficient theory to thoroughly ground the student in the underlying principles of everything he does. Individuals vary, and the same methods of instruction are not adapted to each and every student, although they may be working for the same end. This fact will be acted upon in connection with the new course, and each student will be given individual instruction according to his needs.

New problems are to be found in the boiler and engine rooms, which differ from those that have existed in the past, and a knowledge of mechanics, electricity and the laws of combustion and chemistry is now imperative. Furthermore, their specific application to power-plant operation and their relation to one another are necessary, and this is what will be taught in the laboratories and boiler and engine rooms of the school.

A brief outline of the different subjects considered is as follows, which shows the scope of the work and the thoroughness with which it is to be carried out:

Boiler handling and firing, boiler setting, installation of boiler appliances, testing of boiler appliances, testing of all details that enter into boiler efficiency, steam-engine operation, steam-engine installation, steam-engine repair and regulation, testing of engine efficiency, gas-engine design, installation, repair and operation, and gas-engine construction.

Shop practice, including machine work, machine assembling, foundry practice, both hand and machine forging and tempering, pattern making, pipe fitting, electrical wiring, electrical construction.

Switchboard construction, installation, design, operation; motor and generator construction, installation, repair, operation and testing.

Mechanical drafting, design, and power-plant details, piping layouts, etc.

Power-plant chemistry, including coal analysis, gas analysis, interpretation of gas analysis in relation to boiler efficiency. Scientific measurement of condition of fuel bed, efficiency of furnace, furnace-temperature measurement, measurement of flow of steam, of flow of water, etc.

Theoretical subjects include practical mathematics in all departments important for power-plant work, practical mechanics, heat, power, transmission, steam generation, applied electricity, mechanism of machinery, strength of materials, etc.

The power house will be the headquarters for the practical work of this course. This building is 80x100 ft., and besides the laboratory equipment, it contains the school power plant, which at present consists of 400 hp. of water-tube boilers of the latest type, divided into two units of approximately 250 hp. and 150 hp. respectively and arranged either for natural or forced draft (Fig. 9); a direct-connected generating set consisting of a Corliss engine and 250-kw. generator, which provides light and power for the entire plant (Fig. 3); a large steam-driven air compressor of the straight-line type, for supplying the foundry and various laboratories with compressed air as may be required in the different kinds of work. In addition to this apparatus, all of which is available for purposes of instruction and testing, is a well-equipped steam laboratory, one corner of which is shown in Fig. 8. This is supplied with a variety of engines illustrating practically all of the more important types of valve gear. There are pumps of various types and sizes, closed and open feed-water heaters, a variety of injectors, traps, etc., besides a large number of steam specialties of different kinds. All this equipment is arranged for special study and operation by the students.

A complete unit for the elementary study of boiler testing is provided in the power laboratory. This consists of a 60-hp. tubular boiler of the locomotive type, equipped with its own feed apparatus, weighing tanks for measuring the water, special scales for weighing the coal and equipment for testing the quality of the steam and for making flue-gas readings. Similar tests upon a larger scale will be carried out in connection with the main boiler plant.

Engine testing is provided for in a similar manner, both upon smaller engines arranged for this work and upon the large Corliss generating unit.

Before the opening of the course in the fall a new generating set consisting of a uniflow engine of the latest type with a 60-kw. direct-connected generator will be installed in the steam laboratory especially for testing purposes. This unit will have its own independent switchboard and will be arranged for carrying out complete tests upon both the engine and the generator. It will also be connected with the main switchboard so that the current produced may be utilized for general power and lighting.

Laboratory Equipment

A laboratory equipped for coal, flue-gas and feed-water analysis is located in this building, adjacent to the steam laboratory, the idea being to carry out the same general arrangement as would be found in a large power plant under actual working conditions. A corner of the gas-engine laboratory is illustrated in Fig. 4, which also shows the main generating unit at the end of the room. Here practical work will be done upon gasoline engines, both of the marine and automobile type. A view in the generator and motor laboratory is given in Fig. 1. All the apparatus shown in this room was installed, and much of it was designed and built, by the students of the institute. As far as possible it aims to illustrate exact conditions in different types of special power-plant equipment.

Particular attention will be given to the electrical side of the problem, as it enters so largely into the work of the operating engineer, and the student will be given both practical and theoretical instruction in regard to generators, motors, wiring and switchboard work. Figs. 2 and 7 show groups of students engaged in this line of work. Testing the strength of materials as pertains to the different parts of steam boilers and other power-plant equipment forms a part of the regular course. A view in the testing laboratory is shown in Fig. 5.

In order that the operating engineer may attend to the general repairs of his plant, either personally or in the way of supervision, the student is given a certain

amount of practical work in the foundry, forge and machine shops, views of which are shown in Figs. 6, 10 and 11.

Both day and evening courses are offered. The day courses are of two types—condensed one-year courses for beginners, leading to skilled positions in the trades, and more thorough two-year courses for persons who have already had some practical experience or training and who wish to become superior workmen, master mechanics or foremen, or who wish to fill other important positions of responsibility.

The evening courses are similar in character to the day courses so far as time permits. They are intended for men already employed in trades or mechanical industries and are planned to increase efficiency and aid promotion.

There are eight one-year day courses, five two-year day courses; twelve evening shop courses covering a wide variety of trades and industries and an equal number of evening technical courses. The plan of instructions requires the student in each course to spend half a day, five times a week, in the appropriate shop, acquiring skill and practical experience in his chosen trade. The other half-day is spent in laboratory, drawing room or class room getting the technical and theoretical instruction that is essential to his trade.

Each day in the shop the student is expected to apply the principles which he learned the previous half-day in the class room, drawing room or laboratory.

An employment bureau has been established to assist students in finding satisfactory positions upon completing their courses, and many employers are coöperating with the institute in finding part-time employment for students who need to earn money while attending their courses and in securing permanent positions for them upon graduation. It has been found that satisfactory employment can be secured for all students who have made themselves competent.

Wentworth Institute is on Huntingdon Avenue, facing Fenway Park and in the immediate vicinity of other important educational institutions. The site contains between twelve and thirteen acres, which allows ample space for future expansion.

The main building is four stories in height, 132 ft. long by 66 ft. wide. This provides administrative offices, class rooms, drafting rooms and laboratories for practical mechanics, applied electricity, strength of materials and architectural construction.

The main-shop building and the Parker Street wing are each four stories and basement structures, 145 ft. long by 50 ft. wide, exclusive of the wings. These buildings are devoted to the various shops, laboratories, drawing rooms and class rooms. The foundry occupies the wing at the extreme right and is about 50 ft. square.

Gasoline Substitute

Dr. Miller Reese Hutchison, chief engineer for Thomas A. Edison and himself an inventor, has given to the New York *Times* his own experience in the matter of motor-fuel substitutes which make him inclined to be skeptical of "green gasoline," the cent-a-gallon substitute for real gasoline, a discovery of Louis Enricht, of Farmingdale, L. I., which was erroneously reported to have been bought by the Maxim Munitions Corporation Co.

"Here is the story of an inventor I repeated to Hudson Maxim when he asked me what I thought of the whole thing," said Dr. Hutchison. "I received a message asking me to go over to the Navy Yard in Brooklyn as fast as I could to see a new invention which was going to revolutionize the whole theory of gasoline motor-fuel. It seems that a man had made a discovery, persuaded Washington to allow him to try it out in the navy yard, and it was the day of the experiment. When I got to Brooklyn I found a little group of naval officers and a few engineers gathered about to watch a civilian undertake to run a gasoline engine with a mixture which he said was plain water and a certain simple chemical.

Every precaution was taken to guard against any sort of fraud. The man took about two gallons of pure water, then poured in a tube of his 'discovery,' put the mixture in the engine, cranked up and away she went. I tell you it got all our goats to see the wheel spin and hear the exhaust, realizing it was nothing but water which was presumably burning in the cylinders. I was so much interested that I set to work in my own laboratory that night to see if I could get any idea of just what I had witnessed that day. I had smelled the exhaust to be sure that the engine was not burning gasoline, and that gave me the idea that an acetylene solution must have been used." Dr. Hutchison rigged up a contrivance from an automobile gas-lighting tank. He found that by using acetone to take up the acetylene and then dissolving the acetone in water he had a mixture which he believed would do. The next day he went back to the navy yard, poured his solution into some water and put it into the same engine. It started with the first cranking and went just as it had on the previous day during the demonstration by the inventor.

"You see," said Dr. Hutchison, "the water in each case was merely the vehicle to get the explosive into the cylinders. There was nothing taken from it or added. It was as if a man took the ashes from his furnace and saturated them with oil. They would burn, but then the ashes would be left as before, and unless you put in some more oil you could not get another fire out of them."

Dr. Hutchison was asked if what he had discovered was not a substitute for gasoline. "Why, yes," he said; "so is picric acid, for that matter, but you should have seen those cylinders when our experiment was over."

Feed-Water Heaters

The calculation of the percentage of saving in B.t.u. for each degree of increase in the temperature of feed water heated by waste heat, is made as follows:

Let the total heat of one pound of steam at the boiler pressure = H, the total heat in one pound of feed water before entering the heater = h_1, and after passing through the heater = h_2; then the saving in B.t.u. made by the heater will be

$$\frac{h_2 - h_1}{H - h_1}$$

Example: Boiler pressure equals 100 lb. gage; total heat in steam above 32 deg., 1,188.5 B.t.u.; feed water original temperature, 60 deg., final temperature, 209 deg. F.; increase in heat units, 149; heat units above 32 deg. in feed water of original temperature, 28; heat units in steam above that in cold feed water, 1,188.5 — 28 = 1,160.5; saving in B.t.u. by the feed-water heater, 149 ÷ 1,160.5 = 12.8 per cent. Increase in temperature in degrees Fahrenheit multiplied by the proper tabular figure (opposite the initial water temperature) equals the per cent. saving.

The table and example herewith are taken from Kent's Mechanical Engineer's Pocketbook.

Initial Temp. of Feed, Deg. F.	Pressure of Steam in Boiler, Pounds Per Square Inch Above Atmosphere										
	0	20	40	60	80	100	120	140	160	180	200
32	.0872	.0861	.0855	.0851	.0847	.0844	.0841	.0839	.0837	.0835	.0833
40	.0878	.0867	.0861	.0856	.0853	.0850	.0847	.0845	.0843	.0841	.0839
50	.0886	.0875	.0868	.0864	.0860	.0857	.0854	.0852	.0850	.0848	.0846
60	.0894	.0883	.0876	.0872	.0867	.0864	.0862	.0859	.0856	.0855	.0853
70	.0902	.0890	.0884	.0879	.0875	.0872	.0869	.0867	.0864	.0862	.0860
80	.0910	.0898	.0891	.0887	.0883	.0879	.0877	.0874	.0872	.0870	.0868
90	.0919	.0907	.0900	.0895	.0888	.0887	.0884	.0883	.0879	.0877	.0875
100	.0927	.0915	.0908	.0903	.0899	.0895	.0892	.0890	.0887	.0885	.0883
110	.0936	.0923	.0916	.0911	.0907	.0903	.0900	.0898	.0895	.0893	.0891
120	.0945	.0932	.0925	.0919	.0915	.0911	.0908	.0906	.0903	.0901	.0899
130	.0954	.0941	.0934	.0928	.0924	.0920	.0917	.0914	.0912	.0909	.0907
140	.0963	.0950	.0943	.0937	.0932	.0929	.0925	.0923	.0920	.0918	.0916
150	.0973	.0959	.0951	.0946	.0941	.0937	.0934	.0931	.0929	.0926	.0924
160	.0982	.0968	.0961	.0955	.0950	.0946	.0943	.0940	.0937	.0935	.0933
170	.0992	.0978	.0970	.0964	.0959	.0955	.0952	.0949	.0946	.0944	.0941
180	.1002	.0988	.0981	.0973	.0969	.0965	.0961	.0958	.0955	.0953	.0951
190	.1012	.0998	.0989	.0983	.0978	.0974	.0971	.0968	.0964	.0962	.0960
200	.1022	.1008	.0999	.0993	.0988	.0984	.0980	.0977	.0974	.0972	.0969
210	.1033	.1018	.1009	.1003	.0998	.0994	.0990	.0987	.0984	.0981	.0979
220	.....	.1029	.1019	.1013	.1008	.1004	.1000	.0997	.0994	.0991	.0989
230	.....	.1039	.1031	.1024	.1018	.1012	.1010	.1007	.1003	.1001	.0999
240	.....	.1050	.1041	.1034	.1029	.1024	.1020	.1017	.1014	.1011	.1009
250	.....	.1062	.1052	.1045	.1040	.1035	.1031	.1027	.1025	.1022	.1019

To use the table in the foregoing example: Given boiler pressure = 100 lb. gage; feed-water temperature, original, 60 deg. F. and final 209 deg. F. Look in column of steam pressures headed 100 lb. and opposite to 60 deg. in first column is found 0.0864, which multiplied by difference between initial and final feed water temperatures (209 — 60 = 149) gives the percentage of saving in B.t.u. as 12.8 per cent.

It must be remembered that the saving by the foregoing calculation and the results obtained from the table are the saving in the B.t.u. necessary to convert the given amount of water into steam at the given pressure and not the net saving in fuel as a result of heating the feed water. If the boiler and furnace could be made 100 per cent. efficient, then the saving in fuel and B.t.u. would be the same, but since they are never 100 per cent. efficient, a correspondingly greater saving is made by heating the feed water. It is obvious that if the calculation shows a 10 per cent. gain in B.t.u. and the furnace and boiler equipment is only 50 per cent. efficient, then two B.t.u. in the coal are required to produce one B.t.u. in the steam. Therefore, adding one B.t.u. to the boiler-feed water will effect a saving of two B.t.u. in the coal.

To find the B.t.u. saving in the fuel expressed in percentage, the result obtained from the table must be divided by the percentage of efficiency of the furnace and boiler. For example, a 10-per cent. saving in B.t.u. in a boiler and furnace 75 per cent. efficient means a saving in fuel of $10 \div 0.75 = 15$ per cent. If the boiler and furnace are only 50 per cent. efficient, then $10 \div 0.50 = 20$ per cent., or the saving in fuel is twice that represented by the saving in B.t.u.

It will be seen by the foregoing that the saving in fuel is greater in an inefficient plant than in one of high efficiency for the obvious reason that more B.t.u. are required from the coal to heat the water in a boiler plant that is not efficient than are required in one that is efficient. This feature should not be lost sight of in calculations pertaining to feed-water heating in general and the returns to be expected in plants of any description.

Special Valve Diagram Applied to Walschaert Gear

By E. O. Waters

SYNOPSIS—An analysis of the Walschaert valve gear and the application of a new graphical method of determining the valve travel.

Although the Walschaert valve gear was invented over sixty years ago, its general adoption for locomotive service in America has been a matter of only the last two decades; before that time the Stephenson link motion was standard in this country. To the engineer who is accustomed to slide-valve stationary engines, this latter form of gear seems the simpler; to all intents and purposes it is nothing but the familiar eccentric, eccentric rod and rocker arm for driving the valve, with an additional eccentric and rod which are substituted for the first pair, by means of a link, when the locomotive is to be reversed. But as a matter of fact, the valve in the Stephenson gear is almost never operated by one eccentric alone. Instead, it derives a complicated motion from both eccentrics at the same time, depending not only on their throw, but on the length of the eccentric rods, the length and radius of the link and the manner in which the link is suspended, so that long mathematical formulas are needed to find the valve position in terms, say, of the engine stroke; and even these may put the valve ⅜ in. more or less out of its true place.[1]

The Walschaert gear, however, is simplicity itself, not only from the point of view of the designer, who wishes to obtain the right steam distribution with the minimum amount of computation and preliminary laying-out on the drafting board, but to the repair-shop man as well, to whom accessibility, lightness of parts and absence of fine adjustments are advantages not to be scorned. In fact, a little care exercised by the designer will practically eliminate all adjustments in the shop and reduce the valve-setter's task to that of checking the position of the valve for front dead-center, half-stroke and back dead-center. The following analysis is intended to show what the Walschaert valve motion is, in its simplest elements, and how the position of the valve may be ascertained by an easy graphical construction, for any position of the piston and the reverse lever.

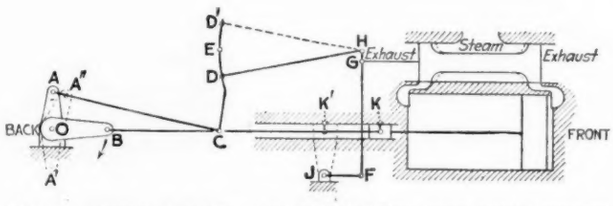


FIG. 1. TYPICAL GEAR ARRANGEMENT FOR HIGH-SPEED STATIONARY ENGINES

Fig. 1 shows an arrangement which, with a few exceptions, is similar to that found on a large number of high-speed stationary engines. Instead of an eccentric there is a short crank set at right angles to the main crank *OB;* and in place of a single rocker arm there are two such arms, *CDE* and *FGH*, each of which has a share in reducing the eccentric throw to the valve travel. These arms are pivoted at *E* and *J* respectively. If the engine begins to turn in the direction indicated by the

[1] Some of these formulas may be found in "Locomotive Operation," by G. R. Henderson, pp. 81 to 88.

arrow, the rod AC will move to the right, moving the valve in the same direction and admitting steam through the right-hand port to the cylinder. At the same time the left-hand port is opened to the exhaust passage. By the time the piston has completed its stroke to the left, the small eccentric crank has described a semicircle and arrived at the point A', the valve in the meantime having moved to a wide-open position and returned to the same place that it occupies in Fig. 1. On the return stroke of the piston the same thing happens, except that this time the valve starts moving to the left and admits steam to the left-hand side of the piston.

To reverse an engine with this valve rigging, it is necessary only to slide the rod DH, called the radius rod, to the position $D'H$. Then, while the valve moves to the right to let steam into that end of the cylinder, the corresponding movement of the eccentric crank will be to the left, and the engine must be running over instead of under. If we wanted to find out exactly where the valve stood for any position of the main crank, we could make a layout of the entire gear, starting with the crank OB in its given position, and by locating various centers and laying out intersecting arcs, gradually work back to the valve and then scale off the distance it had moved away from its mid-position. But this would be very tedious. Instead, it is customary to draw a valve diagram, as in Fig. 2, in which the diameter of the large circle equals the valve travel; the diameter of each small circle equals the radius of the large circle and they are both tangent to the XX axis. Any radius, such as PQ, represents the position of the main crank at a given time, and PR, the part of the radius lying inside of one of the smaller circles, is the actual distance the valve has moved away from mid-position at that instant. Proof of this is as follows:

Suppose for the moment that the rocker arms are eliminated from Fig. 1, so that the large circle represents the path of point A on the eccentric crank. Then when the main crank is in the position indicated by PQ, the eccentric crank will be represented by PT, and the point A will have moved forward a distance UT. By drawing the line SR, a right triangle PRS is formed, identical with the right triangle UTP, since $PT = PS$, angle a = angle b, and angle c = angle d. Therefore, the corresponding sides UT and PR are equal, and PR may be used to represent the forward travel of point A. But the valve travel is proportional to the eccentric travel, so that if we change the scale of the valve diagram to make the diameter of the large circle equal the maximum valve travel instead of the eccentric throw, PR will represent the movement of the valve to the right of mid-position corresponding to position PQ of the main crank.

It will be noticed that the valve, when in mid-position, comes line-and-line with both steam ports; this means that it begins admitting steam at the beginning of the stroke and does not cut off until the end of the same stroke. To economize in the use of steam, it is customary to provide the valve with laps, as shown by dotted lines in Fig. 1, so that when the valve is returning to mid-position it will close the ports sooner than otherwise and permit the steam already in the cylinder to do useful work by expanding during the remainder of the stroke. This good effect of the valve laps, however, brings with it the disadvantage of retarding the point of admission and thus compels the piston to go the first part of its stroke without any steam pressure back of it. In the stationary nonreversing engine this is overcome by advancing the eccentric, or shifting it around the shaft until it comes more nearly in line with the crank (for inside admission valves, as in Fig. 1). This will advance the time of admission, and at the same time the point of cutoff will be advanced, but that can be adjusted in any way that may be desired by changing the valve laps.

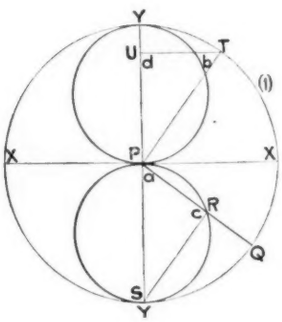


Fig. 2

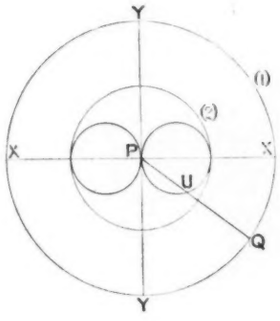


Fig. 3

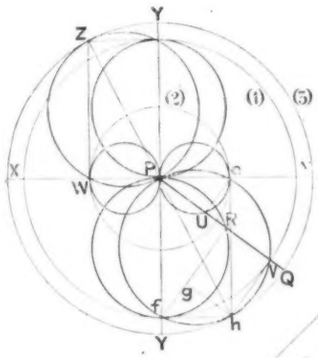


Fig. 4

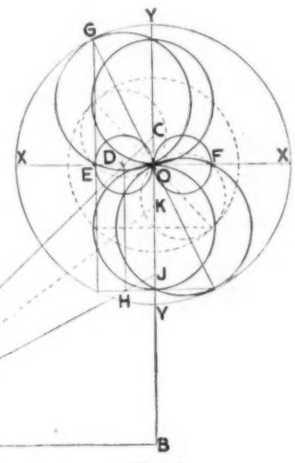


Fig. 5

VALVE DIAGRAMS ANALYZING WALSCHAERT MOTION

But this method would not do where the engine must be reversed. If the eccentric crank were advanced the proper amount for running the engine in the direction shown (as by shifting OA to OA''), this advance would amount to a corresponding retardation when the engine is reversed, and both admission and cutoff would come doubly late. The Walschaert gear gets around this trouble by keeping the eccentric crank square with the main crank and connecting up the point J to the crosshead K', as shown by the dotted lines, instead of having it fixed to the frame of the engine. By making this connection, it is clear that the valve will still get most of its motion from the eccentric crank; but at the same time it will be displaced slightly from the position it would have if moved by the eccentric crank alone, and this displacement will always be in the same direction as the

displacement of the piston from half-stroke position. Thus, when the piston is at the front end of the cylinder, as in Fig. 1, the valve will not be in mid-position, as it would if it were moved by the eccentric crank alone, but it will be displaced to the right; and, if the lever *FGH* is proportioned correctly, the valve will be displaced at least far enough to admit steam to the front end of the cylinder at the commencement of the stroke. Similarly, when the piston is at the other end of the cylinder, the valve will be displaced to the left of mid-position and will admit steam at the beginning of the stroke to the back end of the cylinder. This is irrespective of the position of the radius rod *DH*. In short, the connection of the point *J* to the engine crosshead has given the valve an "advance," which is a true advance no matter whether the engine is running ahead or backward.

The so-called "combination lever" *FGH*, which not only gives the valve its regular travel, but gives it advance, or lead, as well, is the essential feature of the Walschaert gear. This lever is of the floating type, being pivoted at no fixed point; however, its effect on the valve is just the same as that of a simple lever or rocker arm pivoted at *F* and actuated by the radius rod at *H*, plus another lever pivoted at *H* and actuated by the crosshead at *F*. Thus, if point *H* moves forward 2 in. and point *F* moves backward 6 in., the net effect on the valve is to make it move forward a distance equal to

$$\left[\left(\frac{GF}{HF}\times 2\right)-\left(\frac{HG}{HF}\times 6\right)\right] in.$$

If the reader comprehends this action of the combination lever—how it combines two reciprocating motions into one—he has learned what the Walschaert gear is, and the following explanation of the combination valve diagram devised by Prof. J. W. Roe and the writer will be easily understood.

In Fig. 2 it was shown that if *PQ* represented the crank position and the diameter of the large circle was made equal to the total valve travel, then *PR* represented the displacement of the valve from mid-position. By exactly the same method a diagram as in Fig. 3 may be used to show the valve motion that would be caused by moving the valve directly from the crosshead. In Fig. 2 the small circles were drawn with axes perpendicular to *XX*, because the eccentric crank which caused the valve motion was set perpendicular to the main crank; in Fig. 3 they are drawn with axes coinciding with *XX*, because a valve motion derived from the crosshead is the same as one derived from an eccentric crank set in line with the main crank. In Fig. 2 the diameter of circle (1) equals the valve travel; in Fig. 3 the diameter of circle (2) equals the valve travel, and *PU* is the displacement of the valve from mid-position corresponding to the crank position *PQ*. Remembering that the actual Walschaert motion is a combination of two motions, one of which is represented by Fig. 2 and the other by Fig. 3, it is necessary only to combine these two diagrams on one axis to have a single diagram that will give the net result of the separate motions. This has been done in Fig. 4, where *PQ* represents the crank position, *PR* is the valve displacement due to the eccentric crank, *PU* is the displacement due to the crosshead, and *PU* + *PR* is the total displacement of the valve from mid-position.

It would be a great inconvenience to have to measure *PU* and *PR* separately and add them together whenever one desired to find the valve position; and so one more circle is drawn, marked (3) in Fig. 4, which is the resultant, so to speak, of (1) and (2). Its radius *ZP* is the hypotenuse of a right triangle, the other sides of which (*ZW* and *WP*) are the radii of circles (1) and (2) respectively; and the line *ZP* continued is the axis of a pair of circles corresponding to the pairs of small circles in Figs. 2 and 3. Now, if we wish to know the valve position corresponding to the crank position *PQ*, it is necessary only to measure *PV*, *V* being the point at which the line *PQ* cuts one of the circles of the new pair. This will be the amount of the valve displacement from mid-position; for, no matter at what angle we take *PQ*, *PV* always equals the sum of *PU* and *PR*. Proof of this is as follows:

Let *e* be the point at which circle (2) cuts the *XX* axis, *f* the point at which circle (1) cuts the *YY* axis, and *h* the point at which circle (3) cuts the line *ZP* continued. Draw *Ue*, *Rf* and *Vh*; these three lines are all perpendicular to *PV*, because in each case one of them is the side of a triangle inscribed in a circle and has a diameter of the circle for another side. Draw *fh*, *eh* and *gh*, making this last line parallel to *PV*. Then the triangles *PUe* and *fhg* are equal, the sides of one being parallel to the corresponding sides of the other, and *Pe* being equal to *fh*. That being the case, the corresponding sides *PU* and *gh* are equal. But *gh* = *RV*, these two lines being opposite sides of a rectangle; therefore, it is apparent that *PU* = *RV* and *PU* + *PR* = *RV* + *PR* = *PV*.

Application of the Analysis

The practical value of this analysis, in which a diagram has been used to show the resultant valve motion as the combination of two separate motions, may be illustrated by the following problem: Given a locomotive having 28-in. stroke and 6-in. valve travel. The displacement of the valve necessary to admit steam at the beginning of the stroke (lap) is $1\frac{1}{16}$ in., to which is added $\frac{1}{4}$ in. lead in order to admit steam slightly before the commencement of the stroke. The length of the lower part of the combination lever (*GF* in Fig. 1) is $43\frac{1}{2}$ in. What is the total length of the combination lever, and how far back and forth must the radius rod move to obtain the desired valve travel?

Fig. 5 shows the solution of the problem. First lay off the axes *XX* and *YY*, and with *O* as a center draw a 6-in. circle. Then lay off *EO* and *OF* on the *XX* axis, making each equal to $1\frac{5}{16}$ in. (lap plus lead), and draw two small circles with *EO* and *OF* as diameters. These circles, the center of one of which is shown at *D*, could be used to find the valve position at any instant due to the crosshead alone, as previously explained in connection with Fig. 3. The valve travel due to the crosshead is *EF*, of which *DO* is one quarter. Hence if we lay off *OB* equal to the lower part of the combination lever, or $43\frac{1}{2}$ in. (any reduced scale, say one-eighth size, will do), draw a horizontal line *AB* equal to one-quarter of the stroke, or 7 in. (full size) and connect *A* and *D*, continuing the line to *C*, then *CO* will equal the length of the upper part of the combination lever and *CB* will equal the total length, using of course the same scale to which *OB* was laid off. In this way it

is found that $CO = 4\frac{1}{2}$ in. and the total length of the combination lever is 48 in.

We have now disposed of that part of the valve motion which comes from the crosshead and have determined the proportions of the combination lever. By drawing the vertical line GE, corresponding to ZW in Fig. 4, we obtain one-half of the valve travel due to the eccentric crank; and two circles, with diameters equal to GE, should be drawn on the YY axis so as to show the valve position at any instant due to its connection with the eccentric crank, as already explained in Fig. 2. The vertical line HD is then drawn, equal to GE, and AH is drawn and continued to the point J where it cuts the YY axis. Then, since HD equals the half-travel due to the eccentric crank, and $CA:DA$ represents the ratio of the whole combination lever to the lower part of it, $JC:HD$ represents the ratio of the radius-rod travel to the valve travel, and JC equals the required half-travel of the radius rod. By scaling the drawing, this is found to be $2\frac{31}{32}$ in.

This completes the solution of the problem. In addition, circles have been drawn to show the effect of reducing the half-travel of the radius rod from JC to KC, as is done when the reverse lever is hooked up a proportional distance toward the center of the quadrant in which it engages. Numerous events for all possible positions of the reverse lever, can be found from the diagram in Fig. 5 by adding other lines and circles.

Graphic Analysis of Riveted Boiler Joints

By Alphonse A. Adler

SYNOPSIS—The author applies to boiler joints a graphic method of analysis applied many years ago by J. W. Schwedler to bridge structures.

In a lecture Oct. 26, 1867, before the "Architekten-Verein zu Berlin," J. W. Schwedler gave an analysis of riveted joints under the title "Ueber Nietverbindungen." The lecture appeared in print on Nov. 22, 1867, in the "Wochenblatt" of the above society and ran serially on pages 451, 461 and 472. This analysis is by far the most satisfactory of any yet put forward, and boiler designers should be familiar with it.

However, Schwedler gave a graphical method and restricted it to plates and bridges without reference to boiler work. In what follows the idea is translated into analytical form, in which it appears best presented.

It will be assumed that the reader is familiar with the meaning of efficiency, as well as the manner of calculating it. For convenience, the ideal joint will be shown first, since the method of its design will be presented more prominently. After this, the commercial joints with their numerous approximations will be better understood.

Consider a single-riveted double butt-strap joint as shown in Fig. 1. It is necessary first to determine the proper rivet diameter and then to determine the proper pitch. To determine the diameter of the rivet, equate the shearing resistance of the rivet to its bearing (crushing) resistance.

$$\frac{2\pi(d')^2}{4} f_s' = d'tf_c' \qquad (1)$$

from which

$$d' = \frac{2t}{\pi} \cdot \frac{f_c'}{f_s'} \qquad (2)$$

where

d' = Diameter of rivet in inches;
t = Thickness of plate in inches;
f_c' = Ultimate bearing resistance of rivet under double shear loading in pounds per square inch;
f_s' = Ultimate double shear resistance of rivet per single area in pounds per square inch.

The next step is to determine a strip of metal, of width w passing around the rivet, whose tensile resistance is equal to the shearing or the bearing resistance of the rivet. From Fig. 1 the following equation might be written down at once:

$$2wtf_t = R \qquad (3)$$

in which

w = Width of strip around rivet in inches;
t = Thickness of plate in inches;
f_t = Ultimate tensile resistance of plate in pounds per square inch;
R = Resistance of rivet in either shear or bearing, since both are the same.

Hence

$$2wtf_t = d'tf_c' \qquad (4)$$

using the bearing resistance for convenience.

From the foregoing, the pitch of the first row is

$$p_1' = 2w + d' \qquad (5)$$

that is, the strips are placed so that they just touch each other for the most economical joint.

Example: *Single-riveted double butt-strap joint.*

Assume a plate $\frac{1}{2}$ in. thick. Let $f_t = 60{,}000$ lb. per sq.in.; $f_s' = 45{,}000$ lb.; and $f_c' = 100{,}000$ lb. From equation (2)

$$d' = \frac{2 \times \frac{1}{2} \times 100{,}000}{\pi \times 45{,}000} = 0.707 \text{ in.}$$

Also from equation (4)

$$w = \frac{d'f_c'}{2f_t} = \frac{0.707 \times 100{,}000}{2 \times 60{,}000} = 0.589 \text{ in.}$$

Therefore the pitch is from equation (5)

$$p_1' = 2 \times 0.589 + 0.707 = 1.886 \text{ in.}$$

The efficiency of this joint in per cent. may be determined as follows:

$$e = \frac{(p_1' - d')tf_t}{p_1'tf_t} \cdot 100 \qquad (6)$$

using the ratio of the net resistance in tension to the original resistance of a strip of width p_1' before perforation. In the case chosen this is

$$e = \frac{1.886 - 0.707}{1.886} = 62.44 \text{ per cent.}$$

To put the matter in different words, this means that with the assumed unit stresses and with calculated rivet diameter and pitch, the maximum efficiency that can be attained is 62.44 per cent. The efficiency in shear or bearing should be the same as this, since, by the equations the condition of equal resistance has been imposed.

Assume now the conditions that prevail in a double-riveted joint. With the aid of Fig. 2, it will be seen that somewhere along the line *AB*, for example, the unit stress is lower than that at the net section along the line of rivet holes *CD*. This is true since the total load on the strip is the same in both cases, while the area at *AB* is greater than at *CD*. Therefore, the excess metal at this place might be removed by introducing additional holes to the proper extent and adding at the same time more rivets. Thus the total resistance of the joint is increased.

A convenient way of viewing this matter is to consider that the shaded metal under the rivet holes (Fig. 2) is unstressed, and when a sufficient number of these strips of width d' are obtained to make up a strip of width $2w + d'$, another rivet might be introduced in the second row to replace the unstressed strips. Thus there must be fewer rivets in the second row, and this corresponds to an increase of the pitch in row 2. Carrying this process still further, it will be seen that there must be fewer rivets in row 3 than in row 2, and fewer rivets in row 4 than in row 3, and so on. This is the feature of Schwedler's analysis and may be summarized by saying that each rivet is provided with a tension strip equal in resistance to that of the rivet, and room is provided in successive rows to accommodate the increasing number of strips.

To carry on the illustration, a double-riveted joint will be designed for the ideal case.

Example: Since the unused metal from the first row of rivets is equal to a strip of width d', the available metal M_1 for the second row of rivets per pitch is d', and the available metal M_1' per inch width of plate is

$$M_1' = \frac{d'}{p_1'} = \frac{0.707}{1.886} = 0.374 \text{ in.}$$

Since it is necessary to have a width of strip equal to $2w + d'$ in order to insert a rivet in the second row, the pitch p_2' is

$$p_2' = \frac{2w + d'}{M_1'} = \frac{2 \times 0.589 + 0.707}{0.374} = 5.09 \text{ in.}$$

Thus the pitch of the second row is 5.09 in. against 1.886 in. of the first row. The efficiency in tension

$$e = \frac{(p_2' - d')\, tf_t}{p_2' tf_t} \times 100 = \frac{5.09 - 0.707}{5.09} \times 100$$

$$= 83.94 \text{ per cent.}$$

This should also be the efficiency in either shear or bearing. From now on, the process is merely a continuation of the preceding.

Example: The available metal M_2 from the second row of rivets per pitch p_2' is d' and the available metal M_2' per inch of plate is

$$M_2' = \frac{d'}{p_2'} = \frac{0.707}{5.09} = 0.139 \text{ in.}$$

and

$$p_3' = \frac{2w + d'}{M_2'} = \frac{2 \times 0.589 + 0.707}{0.139} = 13.57 \text{ in.}$$

The efficiency in tension, shear or bearing must be

$$e = \frac{(p_3' - d')\, tf_t}{p_3' tf_t} \times 100 = \frac{13.57 - 0.707}{13.57} \times 100$$

$$= 94.72 \text{ per cent.}$$

Example: The available metal M_3 from the third row of rivets per pitch p_3' is d', and the available metal M_3' per inch of plate is

$$M_3' = \frac{d'}{p_3'} = \frac{0.707}{13.57} = 0.0521$$

and

$$p_4' = \frac{2w + d'}{M_3'} = \frac{2 \times 0.589 + 0.707}{0.0521} = 36.2 \text{ in.}$$

The efficiency in tension, shear or bearing must be

$$e = \frac{(p_4' - d')\, tf_t}{p_4' tf_t} \times 100 = \frac{36.2 - 0.707}{36.2} \times 100$$

$$= 98.04 \text{ per cent.}$$

From the foregoing it is seen that the pitch of the successive rows continually increases with a corresponding increase in efficiency. The pitch, however, has no simple ratio from row to row, and as a result such joints present no symmetry. To provide for a duplication of rivet arrangement, approximations must be made. Further approximations will also be necessary to use commercial rivet diameters.

It is now possible to proceed with the design of commercial joints. There are two methods of approach open. The first consists of designing an ideal joint with its calculated rivet diameter and varying pitches and then using the nearest commercial size of rivet and adjusting the pitches of the successive rows so that a simple ratio exists. The second method consists of making the approximations from row to row as the design develops. The former method carried out will appear as follows:

Let $d = 0.75 = \frac{3}{4}$ in. diameter of rivet, hence w should be slightly larger than calculated previously so that it might be assumed as $\frac{5}{8}$ in., therefore

$$p_1 = 2w + d = 2 \times \tfrac{5}{8} + \tfrac{3}{4} = 2 \text{ in.}$$

the pitch of the second row for the ideal joint has the ratio

$$\frac{p_2'}{p_1'} = \frac{5.09}{1.886} = 2.7$$

$$p_2 = 3\ p_1 = 6 \text{ in.}$$

Likewise $p_3' = 13.57$ in. or make

$$p_3 = 2\ p_2 = 12 \text{ in.}$$

and finally $p_4' = 36.2$ in. so that

$$p_4 = 3\ p_3 = 36 \text{ in.}$$

A simple calculation will show whether the rivet will fail by shear or bearing. There results

Shearing resistance = 39,800 *lb.*

Bearing resistance = 37,500 *lb.*

No rivets will fail by shearing, and this method of rupture is excluded. It then remains to set up the equations for a strip 36 in. wide as shown. That is,

(*a*) Bearing resistance of all rivets in a 36-in. strip.

(*b*) Tensile resistance on row 4.

(*c*) Tensile resistance on row 3 plus bearing resistance of rivets in row 4.

(*d*) Tensile resistance on row 2 plus bearing resistance of rivets in rows 4 and 3.

(*e*) Tensile resistance on row 1 plus bearing resistance of rivets in rows 4, 3 and 2.

For convenience, a sketch of the joint will facilitate in the calculation of the efficiencies. Accordingly, the arrangement in Fig. 3 gives a typical unit strip 36 in. wide. It is not necessary to have this particular arrangement of rivets on the actual joint, but however the rivets are arranged with respect to each other, the pitches of the successive rows must be maintained constant. Under any arrangement the number of rivets in a unit strip of 36 in. will always be the same if the strip is symmetrically situated with respect to its neighbors. From Fig. 3, therefore, the resistances for conditions *a*, *b*, *c*, *d* and *e* are

(*a*) $28 \times 37{,}000 = 1{,}050{,}000$ *lb.*

(*b*) $35.25 \times 60{,}000 \times \frac{1}{2} = 1{,}057{,}500$ *lb.*

(*c*) $33.75 \times 60{,}000 \times \frac{1}{2} + 1 \times 37{,}500 = 1{,}050{,}000$ *lb.*

(*d*) $31.5 \times 60{,}000 \times \frac{1}{2} + 4 \times 37{,}500 = 1{,}095{,}000$ *lb.*

(*e*) $22.5 \times 60{,}000 \times \frac{1}{2} + 10 \times 37{,}500 = 1{,}050{,}000$ *lb.*

The resistance of a strip of plate 36 in. wide is $36 \times \frac{1}{2} \times 60{,}000 = 1{,}080{,}000$ lb., so the lowest efficiency will be for condition (*a*)—that is, in bearing—and its numerical value is

$$e = \frac{1{,}050{,}000}{1{,}080{,}000} \times 100 = 97.22 \text{ per cent.}$$

In the ideal joint the efficiency of a quadruple joint by any method of failure was 98.04 per cent. against 97.22 per cent. for this approximation. In Fig. 4 the same joint is shown with a slight change in the arrangement of the rivets. The cover plates are shown scalloped to permit of tight calking.

Fig. 5 shows the latter joint laid out graphically. The tension strips are numbered for convenience. The strained appearance of Fig. 5 is due to the fact that the distance between rows has been made large to prevent the hypothetical tension strips from overlapping on diagonal lines between rivet rows. This in the actual joint is of no importance since with the usual proportions, this method of failure has been eliminated.

The second method of designing the commercial joint will not be considered, since the process is the same as in the ideal joint except that the selection of the commercial diameter and the commercial pitch is made immediately and the available metal is computed by considering the unused plate.

To the writer, at least, it seems best to design the ideal joint first and then to make approximations of rivet diameter and pitches afterward. In this way it is possible to note the limiting efficiencies that might be obtained with the assumed unit stresses. A considerable deviation in the efficiency of the commercial joint is indicative of abnormal assumptions, and these are easily observable on review.

It now remains to see how the cover plates are designed. If the joint is single-riveted then, under ideal conditions,[1] the cover plates should be one-half as thick as the plates connected. For multiple rows this is no longer true. The thickness of the cover plates is dependent upon the efficiency of the joint.

[1]This presupposes that the ultimate unit strength of the plate is unaffected by perforation and does not vary with the thickness of the plate.

For example, it will be observed that the tension strips on the plate run so that all must pass through the space between the last row of rivets. On the cover plate, however, the conditions are reversed. All tension strips must pass through the space between the first row of rivets. By suitably adjusting the thickness of the cover plate, sufficient area might be provided, irrespective of the pitch of the first row of rivets. Also, the scalloping

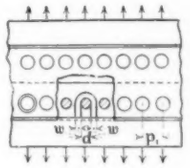


Fig.1

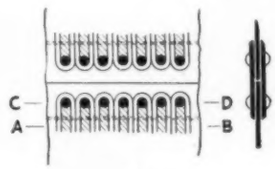


Fig.2

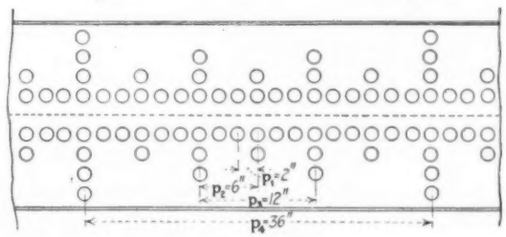


Fig.3

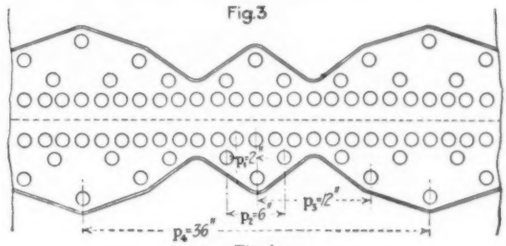
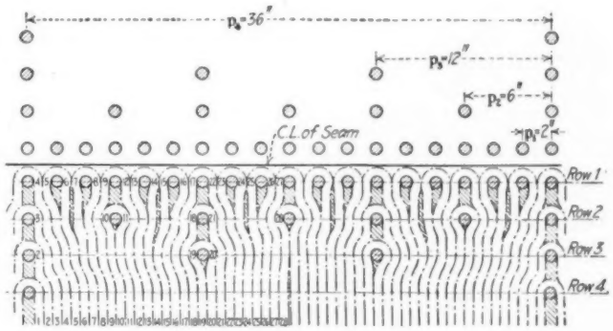


Fig.4



FIGS. 1 TO 5. STRESSES IN BOILER JOINTS

Fig. 1.—Single-riveted, double butt-strap joint. Fig. 2—Consider that the shaded strips are unstressed. Fig. 3—Rivet arrangement in ideal joint. Fig. 4—Plate scalloped to insure tight calking. Fig. 5—The joint laid out graphically

on the last rows does not affect the strength of the joint if this does not encroach upon the metal required for the tension strips. With this in mind, the equations might be written down with little trouble. The total load on a strip of width p_1 is

$$\frac{p_1 t f_t e}{100}$$

and the resistance of the two cover plates is

$$2 (p_1 - d) t_c f_t$$

where t_c = thickness of one cover plate in inches. Since these must be equal,

$$2\,(p_1 - d)\,t_c f_t = \frac{p_1 t f_t e}{100} \qquad (7)$$

from which

$$t_c = \frac{p_1 t e}{2\,(p_1 - d) \times 100} \qquad (8)$$

As an example, take the first commercial quadruple-riveted joint designed. The efficiency of this is 98.04 per cent. and therefore

$$t_c = \frac{2 \times \frac{1}{2} \times 0.9804}{2\,(2 - \frac{3}{4})} = 0.392\ in.$$

or, say, $\frac{7}{16}$ in. So, it appears that, in general, the high efficiency joints require cover plates very nearly equal to, the plates connected.

A few remarks about cover plates may not be amiss. For the high-efficiency joints, the pitch of the outer row of rivets is usually too great to permit tight calking. For this reason the plates should be scalloped, as shown. When it is considered that this is too expensive, the joint should be limited to a double-riveted joint. It is also very desirable to have the inside cover plate of a boiler calked properly so as to prevent leakage and possible corrosion behind the cover plate where it is hidden from view. To insure this, it might be well to leave the outer cover plate uncalked so as to make apparent any leak.

The distance between rivet rows, margin, etc., have been considered. The usual practice in this respect is perhaps satisfactory.

The Wetzel Stoker

Combustion is a chemical reaction. If the means of supplying and mixing air with the combustible products were perfect, combustion would be perfect; and if this were true of stokers or in hand-fired furnaces, the term "excess air" would be but little used. Therefore, it is the aim of every fireman and every stoker designer to have the stoker or grate such that the greatest amount of air will be admitted to that part of the fuel bed where the combustible products distilled are greatest and the least air to those places where the least carbon is to be burned. Between these extremes the air must be graduated. In the Wetzel stoker, Figs. 1, 2 and 3, the grate has been designed so that this condition of air supply conforms to the theoretical requirements, in that the supply of air is greatest where the demand is greatest and least where the demand is least. See Fig. 2.

As the coal enters through the hopper from the bin or elsewhere, it is fed into the furnace by the rocker, Fig. 1, operated by an eccentric. The coking grate is driven by a link connection to the feeder, which moves the coal on to the main grate. The main grate consists of a series of movable bars and a series of stationary ones, the bars of one series being alternately arranged with respect to those of the other. The movable bars are mounted on rockshafts which are driven by an eccentric, see Fig. 3, on the mainshaft operated through the bell crank shown in Fig. 1. The motion of the bar, shown in dotted lines, moves the fuel down the main grate and discharges the ash on the dumping grate, which may be dumped in the usual manner. The movement of the grate, as shown by the dotted lines, Fig. 1, is forward and upward.

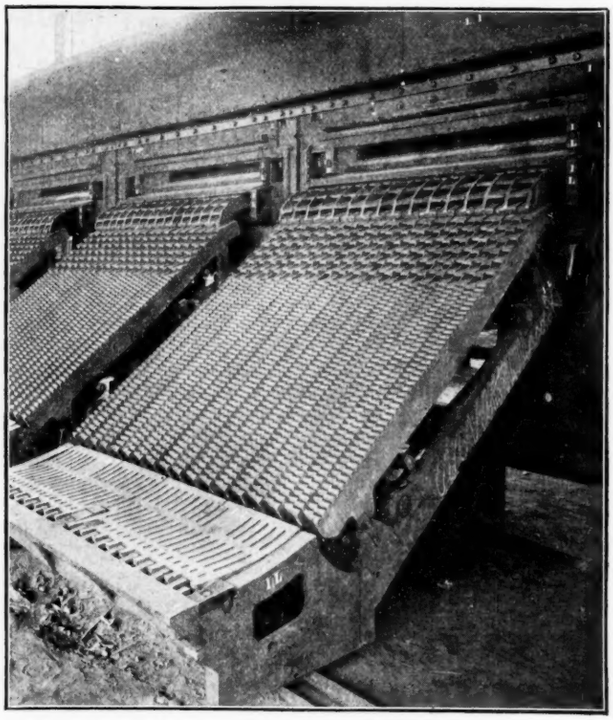


FIG. 2. SHOWING FRAME AND AIR OPENINGS IN THE GRATE

Above the dead plate, coking grate and upper part of the main grate, a reverberatory arch is provided to assist in the distillation of the volatile products. Attention is called to the direction in relation to the fuel bed that the air enters through the grate. Two doors for observation and other uses are provided in the front of the stoker, and a third is made in the side of the furnace setting. The amount of motion of the feeder and grate

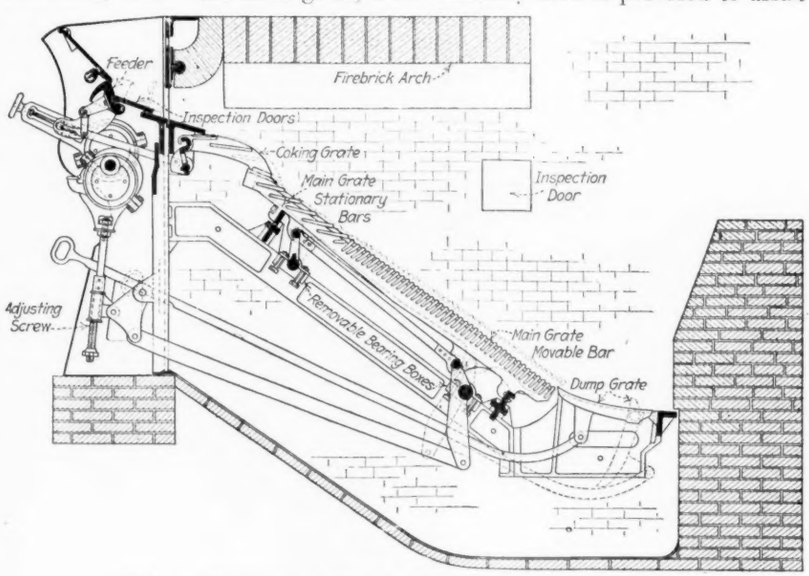


FIG. 1. SECTIONAL VIEW OF THE WETZEL STOKER

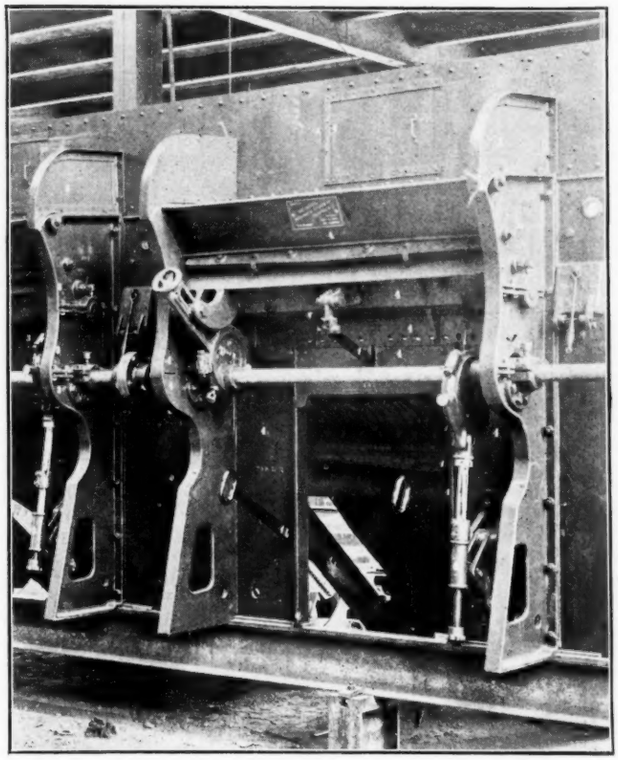


FIG. 3. OUTSIDE VIEW OF THE STOKER

is adjustable by the handwheels shown. Attention is called to the heavy supporting frame. The stationary grates are attached directly to this frame, while the movable ones are supported by heavy cast-iron rockshafts. The bearings of the rockshafts are detachable from the heavy main frame and may therefore be easily replaced. The journals of the lower rockshafts are separate pieces of steel shaft pressed into the cast-iron hub and fastened with setscrews,

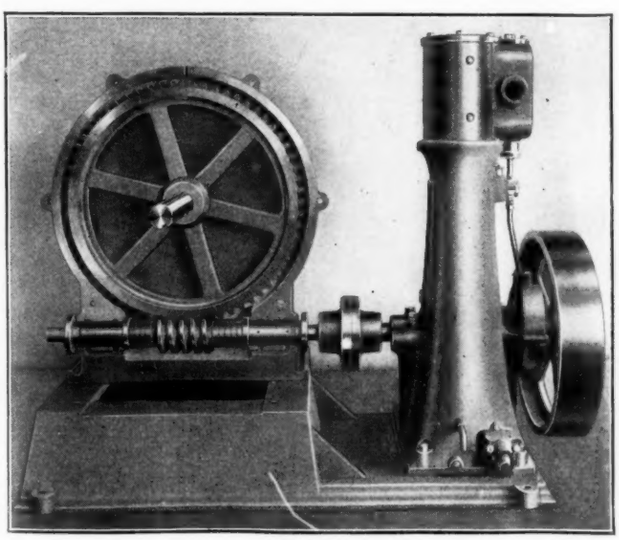


FIG. 4. THE STOKER IS WORM DRIVEN

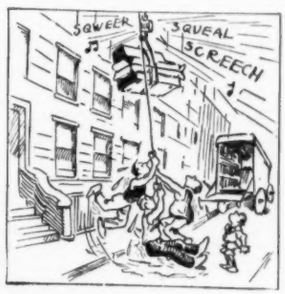
so that those pieces which wear may be replaced easily and at little expense. The bearings for the mainshaft are reamed by a long reamer which will extend through three bearings, thus assuring alignment of the main driving shaft. As shown in Fig. 4, the stoker is worm driven.

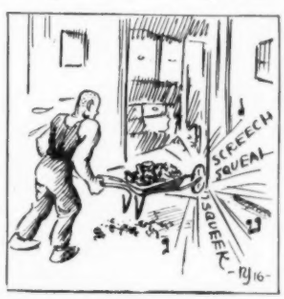
The stoker is sold by the Wetzel Mechanical Stoker Co., 30 Church St., New York City; factories, Trenton, N. J.

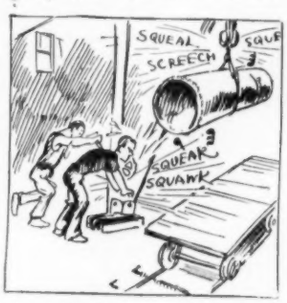
Why Waste Man Power?

By S. F. Wilson

Walking along the street the other day, I watched three men hoisting a piano to a fourth floor via the block-and-tackle route. The pulleys at both ends said, "Squeak, squawk, whee." "Well," I said, "those fellows are just ordinary laymen. They don't know anything about machinery and have never heard of efficiency." Then I went on my way to the power plant the ash-handling system of which I had been told to look over. There I found a block-and-tackle ash-handling "system" with two men straining their backs pulling, and the pulley block hollered just like the piano hoister's. I went out into the "back yard" and there found a fireman pushing a wheelbarrow of coal into the boiler room, and the revolving wheel sang the same tune—"Squeak, squawk, whee." Near the same building I found two men loading some heavy pipe onto a car. They were using a hand derrick on which nearly everything squealed from the mast pulley to the dry wooden handle on the crank. Inside the power house, where steam is employed to do the heavy work, I could hardly hear a sound. Every joint was carefully wiped on the outside and oiled inside. Shafts were bathed in oil and efficiency was kept at its maximum constantly. I have come to the conclusion, therefore, that we engineers are inconsistent in a few things and this is one of them. Man-power is expensive. Nobody questions that. Yet we do not make much of an effort to increase the efficiency of man-power. One man could have lifted the piano easily with an efficient tackle. The ash-handling system could be made so easy-working that it would be almost a pleasure to hoist the ash cans. A four-wheeled car on a track, instead of the wheelbarrow, would save the fireman's energy so that he could do more efficient firing at the vital point. And so forth. Power from coal is cheap in comparison. Why are we so careful in keeping the engine at top-notch efficiency and not the man?







Periodical Inspections of Engine Cylinders should be made to ascertain whether the piston has lost its proper alignment by wear or other causes, to determine if the cylinder has been cut, if the follower bolts are secure and free from fracture, and if shoulders have been formed on the ends of the cylinder from improper lining of the connecting-rod.

A Novel Kerosene Engine

An internal-combustion engine of unusual design is being built by the Field Motor Co., of Grand Rapids, Mich. Although having four cylinders, there are but two cranks

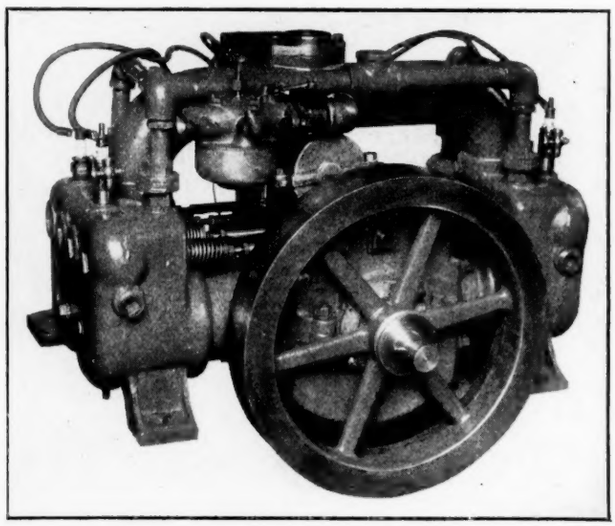


FIG. 1. THE ENGINE ASSEMBLED

and two connecting-rods. The cylinders are opposed in pairs, and the pistons of each pair are rigidly connected by the rods, thus giving the effect of a two-cylinder double-acting engine. The intake and exhaust manifolds extend

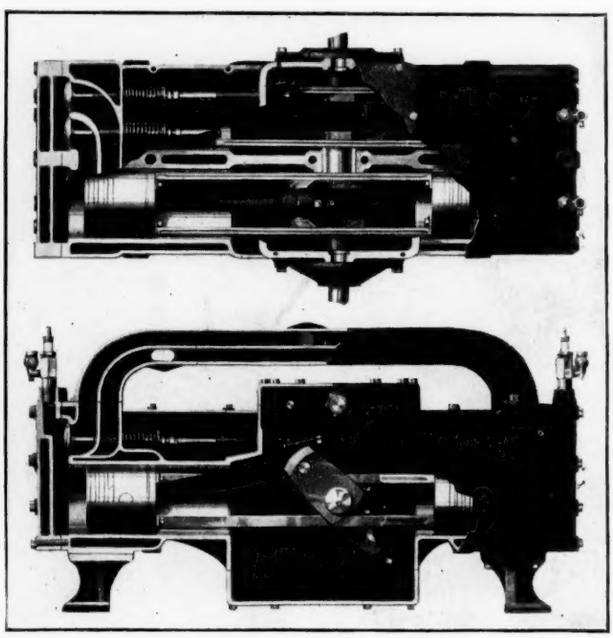


FIG. 2. PARTIAL SECTIONS THROUGH ENGINE

across the top with the valves horizontal and are operated through a bell-crank and camshaft driven by spiral gears.

The engine is fitted with a kerosene carburetor heated by the exhaust, and gasoline is used in starting.

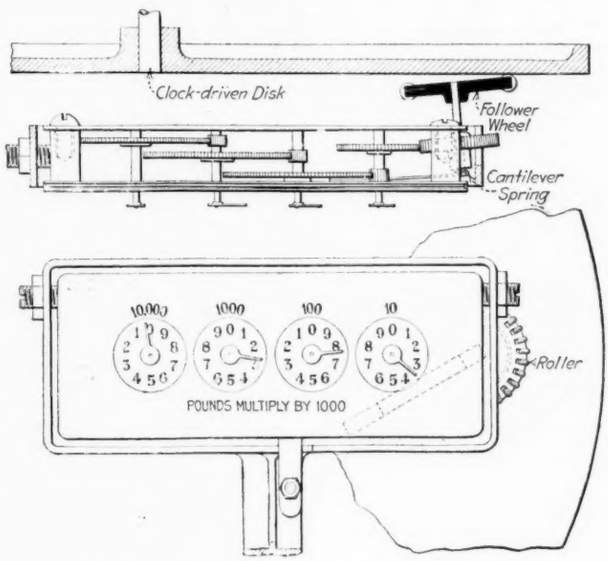
Alcohol Thermometers Sometimes Lose Their Color and are then discarded. The color can usually be restored by plunging the bulb alternately in boiling water and ice water, which treatment will stir up the precipitated coloring matter and make the instrument about as good as ever.

The Bailey Integrator

An interesting mechanical detail of the Bailey fluid meter, described in the issue of June 6, page 807, but applicable to many other purposes, is the integrating mechanism, shown in the accompanying illustration, from which the total flow can be read directly each day or as desired. A clock drives both the chart and the integrator disk, which is 7½ in. diameter and makes two or more revolutions per hour, while the chart makes one revolution in 24 hours.

The counter is suspended from a knife-edge bearing on the clock frame and is moved across the disk by a connecting-rod from an arm which projects down from the back end of the same shaft that carries the recording pen. The follower wheel of the integrator is in frictional contact with the clock-driven disk and is moved from the center toward the circumference as the rate of flow increases from zero to the maximum capacity of the meter.

This follower wheel has a number of rollers on its circumference, so as to cause practically no friction as it is



VARIABLE-SPEED TALLY OR TOTAL COUNTER

moved across the disk and also to prevent the aluminum disk from wearing smooth.

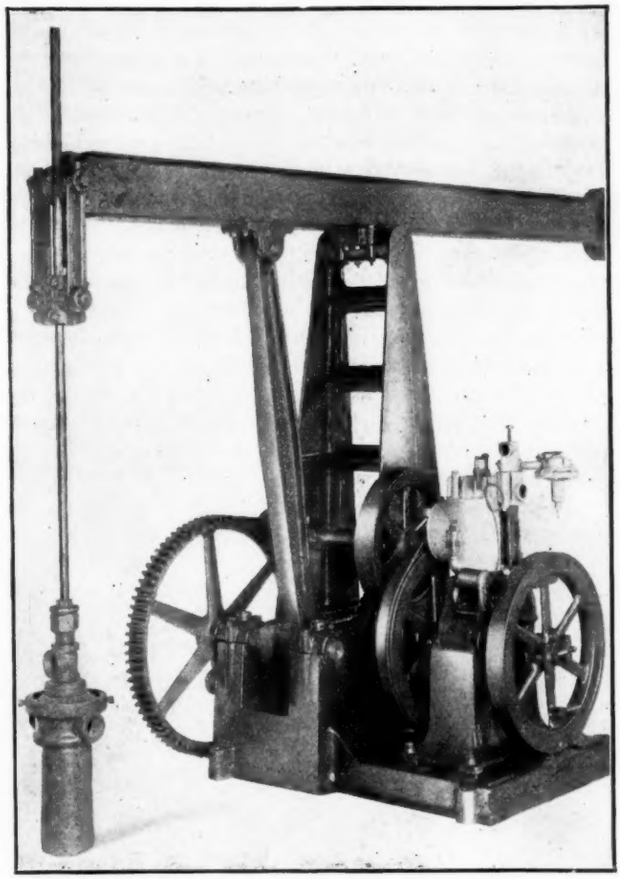
Contact is maintained between the wheel and disk by having the axis of the follower wheel almost perpendicular to the disk, so that the wheel bears on its projecting side edge instead of its extreme outer circumference, giving a greater arc of contact. The wheel has so little inertia that when held in contact with the disk by a cantilever spring, the proper contact between the wheel and disk is secured at all times, regardless of vibration. The counter is driven by this follower wheel through a train of spur gears on the spindles of which are the hands in front of the dials, as shown.

If Steam Has To Be Raised Rapidly in an Idle Boiler, it is very desirable to fill the boiler with hot water, for then the time required for raising the water to the boiling point is saved and in all cases it is advisable to open the safety valves while raising steam so that the steam may blow off freely as soon as the pressure exceeds that of the atmosphere, for heat transmission is enormously increased when a circulation of the water is created by the formation of bubbles. This circulation also materially assists in equalizing temperatures.—C. E. Stromeyer.

Gasoline Pumping Outfit

By Frank C. Perkins

The illustration shows a novel gasoline pumping power plant for oil and gas wells, developed at Olean, N. Y. The 4-hp. air-cooled engine is mounted on the base and the Sampson post is bolted to the base casting, making



MYRICK PUMPING OUTFIT

a rigid construction. The main bearing carrying the crankshaft is in the base, and the second shaft bearing in the frame of the post.

The power from the engine is transmitted through a clutch pinion and intermediate gear to the driving gear, which is keyed to the crankshaft. The latter operates the walking beam through the pitman rod, the stroke being 20 in.

Power House Axioms

Grouchiness proves a heavy liability.

Men readily respond to a kindly command.

Babbitt is cheaper than a man's ill will.

Politics and religion have no place in power-plant management.

Do not forget the little things; they sometimes take root and grow.

Keep up to date. Engineering periodicals are within the reach of all.

Remember that there are men under you that may be as wise as yourself.

Consult your assistants; it makes them feel that they are a link in the chain.

Never make a subordinate do something that you would hesitate to do yourself.

A word of praise is appreciated; a pat on the back sometimes goes deeper than flowery words.

Do not "bawl out" a man in the presence of any of the plant crew. It lowers your reputation among the men. Have the man report at your office, and there give him a chance to explain. You, yourself, may be wrong.

Be kind, considerate and helpful—if necessary, to the point of generosity. Be consistent and self-reliant as far as possible. The men higher up notice these things, and sooner or later your reward is sure to come.

Cost of Installing Four Large Electric Mine Pumps

The installation of equipment to handle 9,500 gal. of water per minute, 8,000 gal. of it by centrifugal pumps, furnishes costs of much value. The equipment may be briefly described as follows:

CAPACITY OF THE PUMPS AND MOTORS INSTALLED

Two 3,000-gal. per min. 10-in. six-stage solid bronze centrifugal pumps with a 325-hp. 700-r.p.m. three-phase 25-cycle 440-volt motor for each pump.

One 2,000-gal. per min. 8-in. six-stage solid bronze centrifugal pump with a 225-hp. 700-r.p.m. three-phase 25-cycle 440-volt motor.

One 1,500-gal. per min. 16-in. stroke 13-in. plunger triplex pump with 150-hp. 500-r.p.m. three-phase 25-cycle 440-volt motor.

Total rating of motors, 1,025 hp.

ACTUAL COST OF PUMPS, INSTALLATION, FOUNDATIONS

	Cost	Per Cent.
Pumps, motors, electrical material, etc....	$26,186.49	68.41
Unloading and transporting pumps.....	227.35	0.59
Labor and material expended in foundations, floors and walls.....	2,373.67	6.20
Installing pumps	1,777.29	4.64
Electrical work	1,359.17	3.55
Compressor pump complete and its erection	320.00	0.84
One 18-in. column and one 20-in., each 268 ft. long.....	5,007.32	13.08
Placing column and batteries in shaft.....	315.84	0.83
Lumber for batteries to hold pipe and for shaft studding	281.89	0.74
Hoisting engineers (handling material and column)	427.24	1.12
Total cost of installation.....	$38,276.26	100.00

The bottom of a shaft that had been recently abandoned was utilized for a pumproom the columns being run up one compartment, and a stairway with landings every 20 ft. being placed in the other compartment. As the amount of steel timber used and the cost of the rock work and sump would vary with different strata, this cost has not been included in the tabulation.

Under normal conditions the 1,500-gal. triplex pump is used to keep down the level of the water in the sump. The total capacity of 9,500 gal. was provided for periods of high water. It is about twice the inflow at such times and so allows a large factor of safety for emergencies or accidents of any kind.

Owing to the acidity of the water to be handled, no commercial foot or gate valves were used, but a priming apparatus with special wood-lined check valves was provided. Long-radius fittings and increasers were used on the piping immediately after leaving the pump, to decrease the friction of the water.

The water lift from the floor of the pumproom to the point of discharge is 268 ft. The pumps supplant two large steam units and were installed during the latter part of 1914 and the beginning of 1915.—*Coal Age.*

Carrying Power of a Bearing is the term used to express the greatest permissible bearing pressure.

Alternator Excitation and Exciters

By Gordon Fox

SYNOPSIS—Methods of excitation, current practice, desirable characteristics of an exciter, and the effect of power factor on the excitation required.

The field poles of an alternator must be magnetized by unidirectional current, which may be obtained in several ways, the most common of which is from a separate source. A second method, now seldom used, employs a rectifying commutator on the alternator itself, while a third method involves a direct-current winding and commutator built on the alternator armature. The latter two types are termed self-excited alternators.

In the last-mentioned method, above the alternating-current windings and in the same slots with them on the armature, there is a separate winding of small conductors connected with a commutator of the ordinary direct-current type mounted on the armature shaft at the opposite end from the collector rings. From this commutator the brushes collect continuous current as in any direct-current machine. This current is carried through the field coils and adjusting rheostat in series to furnish the excitation for the unit. The direct-current auxiliary winding is in reality an exciter winding, located under the main alternator's poles instead of within a separate machine. It is evident that this method is applicable only to units of the revolving-armature type and of small sizes. A disadvantage of this arrangement is that the alternator's load seriously affects the voltage, any lagging current tending to demagnetize the fields. This affects the field magnetism and lowers not only the alternating, but also the exciting voltage.

Separate Excitation for Alternators

The prevailing method of exciting alternators is by separate direct-current generators. Excitation for a number of alternators in a plant may be provided in several ways. In small, isolated plants one exciter is usually provided for each alternator, the exciter being either direct-connected or belted to the main unit. A drawback to this practice is that the main unit is subject to some fluctuation in speed as the load changes, and a heavy load on the line tends to slow down, not only the alternator, but its exciter as well, thus making the drop in voltage greater than if the exciter speed were maintained constant and independent of the main unit. Also, as each machine is dependent upon the other, failure of either means a shutdown for both. Direct-connected exciters are common in hydro-electric plants, where the use of separate water-wheels is thus avoided.

Exciters for single machines should be able to handle 10 per cent. in excess of the maximum guaranteed alternator overload and for the same period as the latter. If the exciter is belted to the main unit, the pulleys should be large to avoid slippage under heavy loads when performance is important. Sometimes belted exciters are furnished in very high-speed ratings because of their lower cost. There is some objection to this practice because high-speed machines are more susceptible to commutation troubles than are those of slower speeds. It is good practice to provide exciters operating below 1,500 r.p.m., about 1,200 r.p.m. being a safe speed for general purposes.

If both the alternator and the exciter are belted, it is desirable that some means be provided to maintain the proper belt tension for the exciter while the alternator is being moved to adjust its belt. If the exciter is on an independent base and not connected to the alternator, it becomes difficult to adjust the main belt without first loosening the exciter belt excessively or else tightening it up to the point where a bearing may heat. After moving the alternator a little, the exciter belt must be readjusted. This difficulty may be overcome in several ways. The exciter may be arranged to slide on its base, and an adjustable spacing rod may be furnished to maintain the desired separation between the units; see Fig. 1. Another method, quite satisfactory but seldom seen, involves the use of an idler-pulley attachment on the exciter. A special pulley end bracket is provided, which carries, besides the idler pulley, a spring to maintain a given tension.

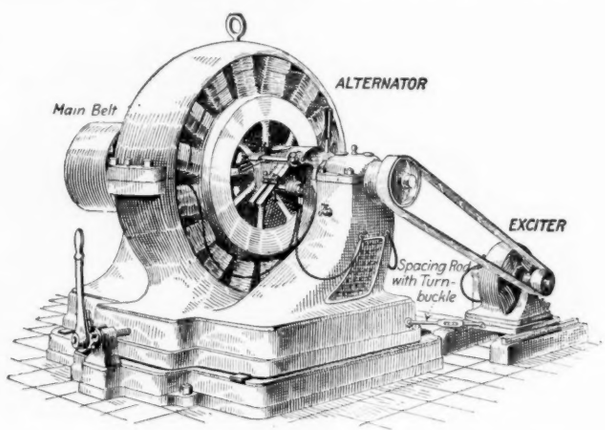


FIG. 1. BELTED EXCITER, SHOWING SPACING ROD

The exciter may then remain stationary, while the relative movement of the machines is cared for by this attachment.

In the larger generating stations separate exciters are usually provided. These may be driven by their own prime movers or by motors. The efficiency of independently driven units is low because of their small size. Motor-driven units are cheaper and efficient, but are dependent upon the alternating-current system. With motor-driven units the induction motor is almost invariably employed. However, motor-driven units cannot be provided exclusively in a plant, unless a storage battery be included, since they are not available for starting up if the system is dead. There should be at least two and preferably three exciter units in a plant. Three units, each capable of exciting half of the alternating-current generators, make a good layout.

Most exciters in small- and medium-sized plants are rated at 125 volts, although large alternators requiring heavy exciting currents are often wound for 250-volt excitation. With the former the alternator field is best designed so that 60 to 70 volts excitation will afford full alternating voltage at no load. With full noninductive

load about 90 to 110 volts will then be required, and full load at 80 per cent. power factor should not require more than 125 volts across the fields.

The magnetic circuit of an alternator includes the stator laminations, the field poles and yoke and the air gaps. The exciting force necessary to produce a given flux depends upon the areas and lengths of the component parts of the magnetic circuit and their magnetic conductivity. At low magnetic density the reluctance of the iron is comparatively small, while the air-gap reluctance is high; with higher densities the reluctance of the iron is a determining factor. The permeability of air being constant, at low densities the flux is nearly proportional to the magnetizing force. At high densities the iron, becoming saturated, causes the flux to increase much less rapidly than the magnetizing force. Alternating-current generators are usually worked at a point upon or slightly above the knee of the saturation curve to secure stable voltage conditions. Without the load the terminal voltage varies with the ampere-turns in the field circuit, as determined by the magnetization curve. When load is applied, the terminal voltage tends to fall off in consequence of resistance drop, armature reaction and armature reactance. The resistance drop includes eddy currents in the conductors, which may be of appreciable amount. The armature reaction depends largely upon the power factor of the load, unity power-factor load having comparatively little effect upon the magnetization. Lagging current, found in low power-factor loads, has a direct demagnetizing influence of considerable proportions. The curves in Fig. 2 show the voltage regulation of an alternator with load at unity power factor and at 90 and 80 per cent. power factors. These curves show the voltage variation as the load comes on, the field ampere-turns remaining constant. If it is desired to maintain the voltage approximately unchanged, it is evident that the field ampere-turns must be increased with increase of load. This is particularly true if the load is at low power factor.

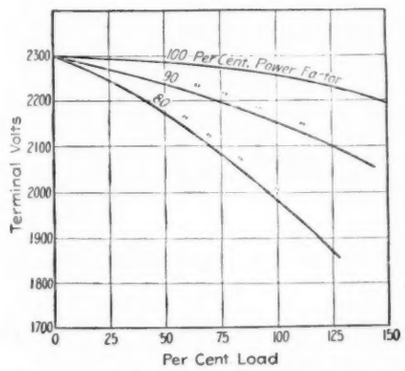


FIG. 2. VOLTAGE REGULATION WITH DIFFERENT POWER FACTORS

An inductive load thus requires much higher excitation than one of unity power factor. This is important in determining the alternator's field design and the exciter voltage and capacity. If a generator is to handle loads of very low power factors continuously, it is desirable and sometimes absolutely necessary that it be equipped with liberal field windings that will not heat with the large exciting current required. Most alternators are now designed with fields sufficiently liberal to carry the excitation required for an 80 per cent. inductive load. Increase in the excitation required for a change of power factor below 80 per cent. is relatively small as compared with an equal change of power factor between 80 and 100 per cent. The increase in excitation required at any power factor is proportional to the synchronous impedance of the alternator, a measure of its armature reactance and resistance. An alternator with high reactance has relatively poor voltage regulation, but runs in parallel with other alternators with minimum cross-currents and feeds but a limited current into a short-circuit. In consequence of these good features most modern alternators are designed with comparatively high impedance, and it is expected that good voltage regulation will be secured through the use of automatic regulators, to properly control the excitation. The exciter capacity must be comparatively large to take care of low power-factor conditions, and the exciters must have high enough maximum voltage ratings to be able to force the required current through the alternator fields. This is a point sometimes overlooked, and it is not infrequently found that, even with all rheostats cut out, it is impossible to maintain the alternating-current voltage under a high inductive load. Then an increase in speed of the exciter, where possible, may prove helpful. Fig. 3 shows how the excitation required by two alternators of slightly different characteristics increases as the power factor decreases.

Exciters are designed with particular reference to their service. Their magnetic circuits are worked at a low point so that full terminal voltage is reached at a low degree of self-excitation. Being worked low on the magnetization curve, a small change in field current causes a marked change in terminal voltage. If the field were saturated, a comparatively large change of field strength would be required to bring about a corresponding change in terminal volts; this would mean sluggish action. Fig. 4 illustrates this point. The iron of exciter A is worked easily, while that of exciter B is more nearly saturated. The increment ab in field ampere-turns causes an increase of 10 volts at the terminals of machine A, whereas, to bring about a change of 10 volts at the terminals of machine B the field ampere-turns must be increased an amount cd, which is considerably greater than ab. It is evident that exciter A is the more sensitive and prompt in action. With hand regulation this characteristic is not particularly desirable, but where automatic regulators are used, it is of material advantage, since the exciter voltage then follows the regulator more closely and rapidly.

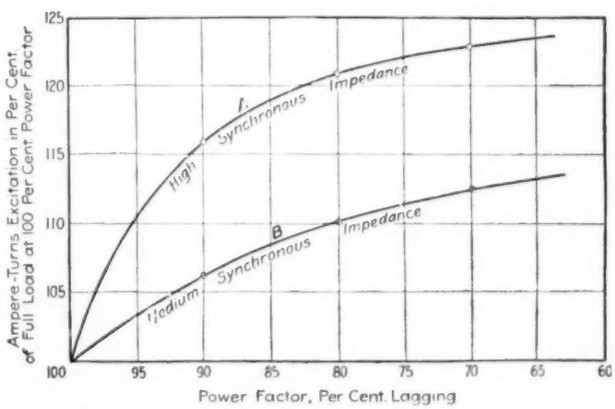


FIG. 3. SHOWING INCREASE OF EXCITATION WITH DECREASE IN POWER FACTOR

Since the fields of exciters are worked at low density, the influence of armature reaction is likely to be pronounced, particularly when the exciter is operating at a terminal voltage of 70 to 90 volts, corresponding to very

weak fields. A liberal air gap is helpful in reducing armature reaction effects, and for this reason a wide air gap is desirable in an exciter. Interpoles are of course effective in overcoming armature-reaction difficulties. Exciters thus afford a legitimate field for their application. To reduce hysteresis lag, the field poles of exciters are usually laminated. This makes for prompt response to automatic regulator control.

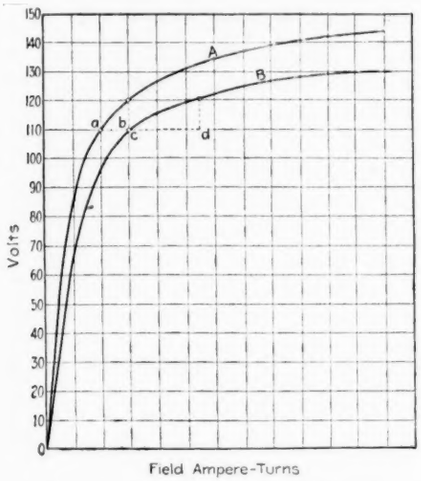


FIG. 4. MAGNETIZATION CURVES

Most exciters are compound-wound in order to maintain the voltage under load. The series ampere-turns at full load should not exceed 30 per cent. of the shunt ampere-turns. The compounding is usually adjusted for flat voltage regulation or for a rise of about 5 per cent. under load. When interpoles are used on compound-wound exciters, the machines should be flat-compounded at 80 volts. At 125 volts the characteristics will then be slightly drooping. If the machines were flat-compounded at full voltage, they would be over-compounded at lesser voltages and might not operate successfully in parallel with other exciters.

Sometimes it is possible to modify the characteristics of exciters in service. If an exciter is found to be sluggish, it is well to determine its magnetization curve by obtaining a set of simultaneous readings of terminal volts and field amperes over a range of values. It is then easy to see upon what part of the curve the operating voltages lie, it being known or determined by observation over what range of terminal-voltage values the exciter operates. If the sluggish action is found to be largely attributable to saturation of the iron, it may be desirable to increase the rotational speed of the exciter. This can readily be accomplished in a belted unit or one driven by an independent prime mover. Under increased speed the exciter will deliver the desired voltage with lesser field strength and at a point lower on its magnetization curve. As previously explained, this will make the machine more sensitive and quick in response to control. Operating under weakened field, a tendency to sparking may arise because of the increase in relative armature-reaction influence. If the field be bored out slightly or shims be removed from behind the poles, the armature-reaction influence is reduced again and the required field current will be about the same as originally, but the magnetic density will remain less than before, so that the desirable point is retained and the undesirable one eliminated. If the exciter were of the interpole type, it would probably be unnecessary to increase the bore, a slight readjustment of interpole strength caring for the changed conditions.

The voltage of an alternator is controlled by varying the exciting current. This variation may be obtained either by regulating the exciter terminal voltage by the exciter field rheostat or simply by regulating the rheostat in series with the alternator's field. For a single unit it is usually preferable to cut out altogether the resistance in the alternator field rheostat and to regulate the exciter voltage. The resistance losses in the exciter rheostat are small because of the light current involved, whereas the current for the alternator's fields may be heavy. The losses in the alternator rheostat represent a useless burden upon the exciter. When alternators are operated in parallel, the exciters being also in parallel, the direct-current voltage is commonly maintained at about 110 volts and the alternating-current voltage is controlled by the larger rheostats. The main reason for this may be found in the fact that the exciters are a little more stable with the higher voltage corresponding to fair saturation of their fields. Where paralleled machines are controlled by a Tirrill regulator, the alternator rheostats are cut out largely or entirely and the alternating voltage is regulated by automatic variation of the exciter voltage. The large rheostats are then used only to minimize cross-currents.

In this connection it might be well to review the relation of excitation to load division of alternators in parallel. In direct-current machines, the load is apportioned among the individual units by rheostat manipulation. This does not apply with alternators. In direct-current generators the series fields act to equalize the loads. A similar result is obtained with alternators, but in a different way. The over-excited machine generates a cross-current which flows through the local circuit of the two alternator armatures. This cross-current bucks the excitation of the over-excited machine and aids that of the lesser excited machine. A change of excitation thus merely modifies the cross-currents flowing between the two machines and does not in any way affect their load division. The division of load depends entirely upon the prime movers.

Tempering and Annealing

By A. H. Hervey

An engineer is often called upon to make various tools and parts of machines which require a knowledge of tempering and annealing the various common metals.

Steel is roughly divided into four classes, according to the percentage of carbon contained and its capacity for being welded: Soft steel, which is not temperable but is easily welded; medium steel, which takes a poor temper and is weldable; hard steel, which is temperable and welded with difficulty; and very hard steel, which takes a high temper and is not weldable.

A tool of hard steel that requires shaping in a machine or filing should first be thoroughly annealed. To do this, heat the steel slowly and evenly to a dark red, then cover with ashes or powdered lime to allow it to cool slowly—the slower it cools the softer it will be. A quicker way is to use the water-annealing method. To do this heat the steel as before and hold it in a pair of tongs until all color is gone or so that when rubbed with a piece of

clean pine it will no longer char the stick, then immerse it in a bath of cold water. It is now ready to be machined. Annealing weakens steel slightly, but renders it better able to stand shocks.

To temper or harden tool steel, heat it slowly and evenly to a red heat for about 2 in. from the cutting edge, then immerse it in a bath of cold water or oil to a depth of 1½ in. till the point is cold. Take the tool out of the bath and polish the scale or coating from the point with a piece of emery cloth or other abrasive, then wipe the surface with a piece of oily waste. Watch the polished surface as the color comes down from the hot shank. When the edge has reached the desired color, which can be learned only by experiment and test, immerse the entire tool in cold water. As a guide it is to be understood that the darker the color the softer the edge will be. The last operation is known as drawing. The proper color is to be determined then, by the use for which the tool is intended.

Soft or medium steel that will not take a temper can have its surface hardened to a depth of about a hundredth of an inch by casehardening. This is done by heating the steel to a dark red and placing cyanide of potash on the part to be hardened, then putting it back in the fire for a few minutes so that the cyanide will be absorbed by the hot steel, and plunging it in a bath of cold water.

Copper and brass may be annealed by the opposite means to that used for steel—that is, by heating to a dark red and plunging into cold water or allowing it to cool in the air. If brass is heated too hot, it will fall to pieces. If properly done, brass and copper can be annealed many times without injury.

Troubles with Commutators

By C. V. Hull

In a large manufacturing plant where there were eight to ten dynamos and about two hundred motors in service most of the time, commutator troubles were quite frequent. The commutator of one dynamo would not take a polish; it did not spark badly but seemed to be a trifle roughened. For some time a sanding block was kept near the machine and used frequently. Then the electrician decided to put in harder brushes and under-cut the mica in the commutator. These changes ended the trouble and the dynamo afterward carried a heavy overload.

Another machine caused some trouble because oil got on the commutator. This was overcome by sliding a snug-fitting collar over the shaft. The collar was so located that the oil was thrown against the inside of the bearing pedestal and thus returned to the oil well.

There were several flash-overs with one dynamo. This was a second-hand machine. The electricians found that the surface at the inner end of the commutator and the terminals of the coils were very dirty. Evidently the commutator had been turned up at some time and not thoroughly cleaned. After the dirt was cleaned out the flash-overs ended.

The speed of one of the dynamos was rather high, the pulley was about 12 in. diameter. Consequently the heavy two-ply leather belt running from a twin-cylinder gas engine jerked the armature considerably and made it necessary to keep a stiff tension on the brushes. Comparatively soft brushes were used and changed as often as the wear demanded. Good service was had from the dynamo except that the small pulley was hard on belts.

A balancer set was used because the plant furnished 220-volt current for three-wire distribution. One of the balancer sets was made up of two 110-volt generators. These dynamos were fitted with the old-style metal brushes, which were made of layers of copper mesh cloth firmly compacted. Much care was required to keep them in order. If a brush wore so that the setting was not correct, sparking began at once and the brush was soon badly burned. It was the practice to set the brushes at least once each day. Commutator compound was used freely, but in spite of these attentions the sparking and cutting was annoying. The electrician finally got a set of brush-holders for carbon brushes. After the carbon brushes were put in, the balancer required but little attention beyond an occasional oiling of the bearings.

Commutator Trouble in Foundry Motor

One motor used in the foundry showed signs of breaking down between the commutator bars. This was not strange, for the motor was working in a very dirty place. The oil that naturally worked out of the bearing caught and held the dust that, no doubt, contained fine particles of iron.

This motor was kept in service for some time by digging out the charred mica. The holes were then plugged with a paste made of chalk and silicate of soda, chalk being added to the silicate until a smooth, easy-working mixture was obtained. This paste hardens quickly and is easily dressed with sandpaper. The conditions of service were so severe that it was at last found necessary to take out the armature and put new insulation between the commutator bars. However the paste made it possible to run for several months during the rush season.

Owing to a number of short-circuited coils it was necessary to rewind the armature of a 15-hp. motor. Coils ordered from the manufacturer of the motor were used. When the motor was ready for service it would not work well. The commutator was examined carefully and everything seemed to be in good order, but there was considerable sparking and the motor would not pull.

A more careful inspection showed that the coil terminals were not in the proper slots. It was one of those armatures with an even number of coils and an odd number of bars in the commutator. Hence there is one dead coil when the winding is properly done. When half the coil terminals were moved over one slot and the dead coil arranged the motor ran well.

One of the most troublesome motors was on a hoist, or elevator. This motor ran in a very dirty place and in both directions, which prevented the brushes wearing to a good fit; besides they often stuck. Sometimes dirt and grease formed on the commutator until the motor sparked savagely or even stopped from open circuit. Though this motor had daily attention the electricians were unable to overcome the trouble because of the dirt. Yet that commutator never seemed to be damaged by the sparking. Perhaps the grease and dirt that fell from the cable caused the sparking, for the commutator did not seem to burn.

The foregoing are a few of the troubles experienced with about two hundred commutators. In most cases the troubles were due to overloads, dirt or poor insulation.

Field-Rheostat Connections

By Gordon Fox

The speed of a direct-current motor depends upon its field strength. When the field is strong, the armature rotates at reduced speed since, with high flux density, the required counter-voltage may be generated at low speed. As the field is weakened, the armature must rotate faster to maintain the counter-voltage at the required value. If the field circuit of a direct-current shunt motor is opened, the motor will race at tremendous speed if not held down by a rigidly coupled load or disconnected by a circuit-breaker or fuse almost instantly. Not infrequently motors are damaged in this way.

Where a field rheostat is used for speed control, it is always a vulnerable point in the field circuit. If the contact finger makes a poor contact with the buttons

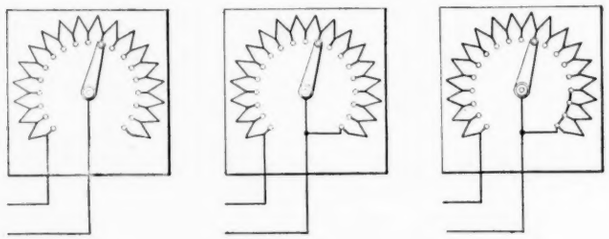


Fig. 1 Fig. 2 Fig. 3

FIGS. 1 TO 3 SHOW INTERNAL CONNECTIONS OF FIELD RHEOSTATS

or studs, an open circuit occurs and the motor will race or blow the fuses. This is likely to occur when a field rheostat is connected as in Fig. 1. To avoid this occurrence, motor field rheostats are often connected as shown in Fig. 2. Here the total rheostat resistance is always in the circuit, the contact arm merely short-circuiting part of it. This is a safer arrangement than that shown in Fig. 1, for obvious reasons. Almost any rheostat not connected as in Fig. 2 is adaptable for such connection, and the precaution is well worth the practice.

Adjustable-speed direct-current motors are not usually tested at the factory with their controllers and it is often found that the rheostat resistance is greater than is required, so that the motor will reach excessive speeds if the rheostat is placed on the last positions. It is unsafe to leave a rheostat in this condition as the safe speed will surely be exceeded sooner or later. Therefore it is well to short-circuit a part of the resistance, as shown in Fig. 3, the proper amount being determined by testing the speed of the motor, placing the controller arm in the position giving maximum rated speed and short-circuiting all resistance beyond that point by soldering the contacts together.

Furnace Arch Quickly Renewed

By R. L. Ellis

It became evident that the bottom arch of one of our Murphy furnaces would have to be replaced. This constituted somewhat of a problem, as the condition of load was such that the furnace could not well be spared for any length of time. Previously it had taken practically a week to accomplish this job, and the problem was put up to the operating engineer, O. A. Carneal, to devise a way to accomplish this repair in much shorter time than had been usual. The stoker to be repaired is 9 ft. wide by 10 ft. long, and is under a 400-hp. Heine boiler.

In planning a method of procedure it was determined to try to replace the lower arch without disturbing the upper one. This was, in the estimation of the engineer, possible because there is an air space of some 4 in. between the two. It was also found that about five workmen were all that could be used in the work on account of the confined space. In actually doing the job the grate bars and other obstructing work were removed and the lower arch taken out. This took approximately four hours for the five men.

The arch supports were put in place, they having been made for a previous job and saved. The first row of arch blocks were then placed on each side and carefully fitted to the supporting pieces so that the other sides of the blocks were in alignment as shown by straight-edge. This made it easy to fit the remainder of the blocks. Work proceeded from the sides toward the middle, or keystone, of the arch until there was only space enough for one man to put in the remaining blocks and keystones. The air baffles were put in as the work proceeded and were laid with an expansion joint of asbestos fiber.

A detail that was new to those doing the work was tried out and is given here for the consideration of others using similar arches. The arch has not been in service long enough to say whether it is desirable or not. This detail had to do with the fitting of the keys.

Heretofore keys have been put in and driven home with effort to get a perfect fit over the entire bearing surface. The keys put in in this last job were given a slightly different pitch toward the narrower edge so that they fit to a bearing surface only on the outlet half of the surface. The theory on which this feature was based was that when the arch gets hot and expands, the tendency is for it to rise. This increases the pressure on the portion of the arch next to the fire. Also this side expands most on account of its becoming hotter than the other side. Add to this the fact that the highly heated portion of the arch blocks are able to withstand less pressure successfully, and you have the reasons for this detail. The space left was approximately $\frac{1}{16}$ in. on each side of the key, or a total of $\frac{1}{8}$ in.

It is believed that this will tend to make the arch last longer than with the other construction, but it has not been in service for a sufficiently long time to determine whether this will prove out or not.

The whole arch was laid with high-temperature cement mixed with just enough fire-clay to get good working. The blocks were dipped in a mixture of about the consistency of cream.

The total time of replacing the arch was ten hours for a gang of five men. One man earned 30c. per hour, one 17½c. and three 12½c. each. The job was therefore 14 hours for the gang and cost $11.90, exclusive of the engineer's time, he having planned the whole and fitted all keys. All labor was performed by the regular force employed around the plant, and there was not a brick mason on the job at any stage of it.

To Make a Shellac Solution to use on pipe threads for hot or cold water, use a 10 per cent. solution of ammonia to cut the shellac. Tighten the threads into the fittings as firmly as possible by hand (no wrench needed) and when dry, pipe threads up to 1¼ in. will be absolutely water-tight if the threads are first freed from oil. For pressures over 20 lb. use a pipe wrench.

Editorials

Intermittently Operated Boiler Plants

Steam plants that are operated intermittently, as in sawmills, sugar mills, storage houses for natural ice and the like, are often permitted to deteriorate during the periods of inactivity, when as a matter of fact the depreciation during these intervals should be virtually nil—and would be if proper care were exercised.

Where engines, pumps, motors and other apparatus for developing or consuming mechanical power are left to the ravages of rust and decay, the loss must generally be repaired before the plant can again be operated. Concerning the boilers, however, it is a lamentable fact that a renewal of activities is not always contingent upon restoration to a prime condition of serviceability, and so the task is often postponed to an indefinite "after awhile," the condition of the boilers standing in the meantime as a continual menace to life and property. The large number of explosions which the statistics of insurance companies show to have occurred after periods of idleness, as for example in lumbering regions, proclaim the truth of these statements.

There is a reason for the conditions noted. Plants that are operated intermittently are not those that attract a high grade of engineering talent, either as to skill or fidelity to duty. Inferior operators are frequently employed, and when closing-down time comes, a man of this type is apt to be more concerned about the prospect of migrating to another field of activity than he is with taking suitable precautions to safeguard the outfit from decay during the interval of rest. With no assurance that he will be so situated as to warrant a return to the job when the next working season opens, an engineer with loose ideas regarding the ethics of his trade will not be inclined to bother himself about the future of the plant he is leaving or whether oxidation and corrosion eat into its vitals and make it unsafe for the next man who starts it up.

In communities where boiler-inspection laws are rigidly enforced, danger to the public from this species of neglect is rarely in evidence. The inspector sees to it that the neglect is adequately counteracted before the boilers again go into service. But the loss to the owners of the intermittently operated plants goes on nevertheless, for it is not within the province of the law to withhold a man from squandering his money by letting his property lapse into decay and ruin.

The fact that the owner of an intermittently operated plant permits this sort of negligence is, in most cases, evidence of a failure on his part to grasp the real consequences. Very often the owner has no true realization of the injurious effects which want of precaution is sure to bring about. But the man having a license to call himself an operating engineer knows these things, and upon him the odium chiefly rests.

The plants to which these remarks refer are mainly of small or medium capacity, and ample protection for them while out of service can readily be applied with small expense in labor and material. A gallon or two of cylinder oil, also of crude oil; some asphaltum paint; a pound or two of graphite, likewise of white lead—these are the materials mostly needed. Carefully applied, they will hold the plant immune from deterioration for many months.

*

Power-Plant Operation

It is comparatively but few years since power plants were limited to the operation of mills and factories, and the equipment, even in the largest, consisted of a battery of boilers, one or more slow-speed engines, together with a simple outfit of accessories in the way of feed apparatus, and possibly a condenser. The exhaust was usually discharged outboard, and steam for heating the buildings and that required for industrial purposes was taken directly from the boilers through pressure-reducing valves. Although the greater part of the condensation from the heating system was returned to the boilers in the larger plants, the waste of fuel was a large item in many cases through steam and hot water being blown directly outboard. This condition was especially prevalent in small manufacturing plants. The duties of the engineer consisted in keeping his engine running during working hours, attending to necessary adjustments and repairs and maintaining a general oversight of the boiler room. The duties of the fireman were principally to shovel coal and remove ashes. Although sufficient intelligence was required to keep up steam pressure and maintain a fairly constant water level, the first requisite was brawn. Very little attention was given to efficiency, the principal object being to produce the required power.

The modern plant includes not only the boilers themselves, but supplementary devices in the way of mechanical stokers, forced or induced draft, superheaters, economizers, automatic alarms and feed-water apparatus. To all this must be added the vast amount of electrical equipment, much of which has come under the charge of the operating engineer. To design such a plant requires the combined services of the mechanical, steam, electrical, heating and ventilating, and the civil engineer, all highly trained specialists in their own particular lines. But after the plant is completed in all its various and widely differing parts, it is turned over to the care of a very different type of man—the operating engineer.

He may have assistants, but he alone is responsible for the smooth and continuous running of this aggregation of machinery. Not only must he keep it in continuous operation, but he must do so with highest efficiency and minimum depreciation. The cost of power is today as important as the cost of any other manufactured commodity, and the man in charge of a plant of this kind is not only an engineer, but a manufacturing superintendent as well, studying methods for reducing the cost of production in his special line of goods, namely, power.

What has been done during the past twenty or thirty years to train men to cope with these changed conditions?

Great technical schools have grown up, equipped with laboratories where problems involving power-plant design are carefully worked out under the direction of experts. But the men who are to be the operating engineers seldom enter them.

To be sure, a limited amount of experience in the actual handling and testing of power-plant equipment is given the students in these engineering schools, but it is impossible to train them to any great extent in practical power-plant work as actually carried on by the operating engineer; nor is there likelihood that many will seek this field for employment. Thus power-plant design and testing have been cared for and training is available to enable men to keep pace with the rapid advancement along this line.

But how about the operating engineer? What has been done to give him an opportunity of keeping abreast of the mechanical, electrical, civil and heating engineer, the operation of whose combined work he is held responsible for upon its completion? Little or nothing, we are forced to admit, compared with what has been done for the designing engineer. To be sure a well-trained student from one of our technical schools occasionally finds his way into the operating field, but this is the exception. Whenever it does happen, however, the value of the limited power-plant experience received in undergraduate work emphasizes the need of more adequate opportunity.

Now what have been the opportunities of those filling the positions of chief engineer in our power plants, both large and small? These places are filled principally by men who have started at the bottom and grown with the requirements of the plants that they have worked in. Larger and more complicated plants have been built, and the men have simply been obliged to fit themselves as best they could to take charge of them and have made good through effort and sacrifice. They have done it partly by studying the plant itself and partly by studying the underlying principles of each new piece of apparatus, either from technical papers, from textbooks, in evening schools, or by means of correspondence instruction.

It would seem that the time has come when the operating engineer should have an equal chance with the mechanical, electrical and civil engineer to fit himself for his calling, which is of the same degree of importance and which also calls for the equal of intelligence although a radically different sort of training.

Such an opportunity is being offered by the Wentworth Institute (see article on page 152) by the adoption of a course in power-plant operation, the purpose of which is to fit young men to become operating engineers, as thoroughly grounded in that particular branch of engineering as are those students who have taken the courses pertaining to other branches of engineering endeavor.

Chicago, Milwaukee & St. Paul Electrification

Since our water powers are the only source of energy that is self-perpetuating, the question of their utilization becomes one of vital importance, as the more water power that is used the less will be the demands upon those sources of energy that are not susceptible to renewal. Therefore the system that has been so successfully put into effect in the electrification of four hundred and forty miles of mountainous railway on the Chicago, Milwaukee & St. Paul, now nearing completion and described elsewhere in these columns, is a step toward true conservation.

There are many significant features about this undertaking; notably, the use of direct current at three thousand volts and the fact that it is the largest undertaking of its kind ever attempted. The change from steam to electricity has been brought about by purely economical requirements and not from any local necessity (such as doing away with the smoke nuisance or to meet other local conditions) which has characterized the electrification of many of our railway terminals. This achievement has been referred to as "not a theorist's fancy or a railroad president's whim, but the logical result of electricity coming into its own."

The power for this project is supplied entirely from hydro-electric stations, consequently the saving in coal per year is enormous. Regenerative braking is used; that is, on descending grades the motors are converted into generators and give back to the system a large portion of the energy absorbed by the train on the ascending grade. This returned energy is used to haul other trains up grade, or is returned to the high-tension system to be used for other purposes, thereby operating at a greatly improved efficiency. In this way approximately fifteen per cent. of the total power is saved, but in the future, when traffic becomes heavier and the system is double-tracked, allowing a more economical operation of trains, even a greater economy may be expected. One other feature which is characteristic of another of our national movements is that maximum safety in operation is assured. There always has been no inconsiderable amount of danger attending the handling of heavy trains on mountainous grades, depending on air brakes for their control. With regenerative braking maximum safety is obtained.

The success attending this achievement is far beyond the expectation of all those concerned and is another monument to the courage, foresight, ingenuity and ability of the American engineer and captain of industry.

Testifying before the Thompson Investigating Committee, an expert witness is reported, by one of the New York dailies, to have stated that "gas is sold to the public in New York at a uniform rate regardless of the quantity used," therefore, "as there is practically no difference in the business of manufacturing and selling gas and electricity, there can be no proper business reason for the widely varying and extortionate prices charged by the New York Edison Company." Such utterances lead to misconceptions in the lay mind and make it all the harder for the public and the central-station managements to arrive at a rational understanding regarding rates. They should be discredited just as strongly as extravagant statements on the other side of the controversy.

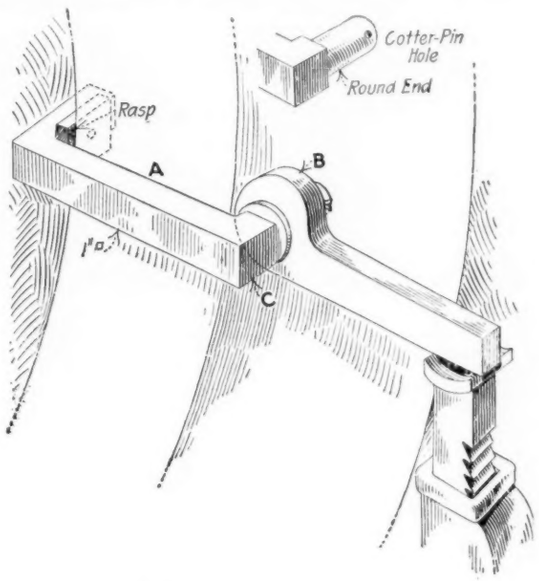
What is in a name? A steam-driven power plant may give just as good service when operating under a water-power name as it can with any other. This is true of the Victoria Falls Power Co.'s plants at the Rand, in South Africa, which, although having a hydro-electric name, are entirely steam-driven. The total capacity of the system is two hundred and twenty thousand kilowatts.

Correspondence

An Engine Turning Jack

We have a 450-hp. engine, the flywheel of which has a 24-in. face and a rim 9 in. thick. The rig used for turning the engine off the center marred the face of the wheel where it bit.

I devised a home-made arrangement that will not mark the wheel. It consists of a piece of 1-in. square steel, made like *A*, and a piece of flat iron ¾ in. thick made like



RIG FOR TURNING A FLYWHEEL

B. This piece is put on the rounded end *C* of the clamp, with a washer on each side and a cotter pin through the end of the round piece. On the square end of the arm *A* a 2-in. piece of an old rasp was riveted so as to bite the inside of the rim. A lifting jack is used on the outer end of the piece *B*. There is no slip to this rig, as the heavier the lift the tighter it takes hold.

Wendel, W. Va. JOHN C. MORTON.

Engine-Economy Comparison

A lot has been written recently about the wonderful advancement in the economies of steam turbines in the last ten years, particularly in the new units of 25,000 to 35,000 kw. There seems to me to have been just as remarkable advance in smaller units, so that private plants can still easily meet central-station rates with proper equipment and operation. I have endeavored to get together some of the fuel-cost data of different types of engines taken from acceptance tests and guarantees.

In a recent acceptance test of a Buckeyemobile a steam rate was obtained that required 1.3 lb. of 14,400-B.t.u. coal per indicated horsepower-hour, or about 2.14 lb. per kw.-hr. With coal at $3 a ton, this would give a fuel cost of 3.2 mills per kw.-hr. In units of from 100 to 250 kw. and above, the fuel cost is the largest item.

Another type of engine has a guarantee of 11⅜ lb. superheated steam per indicated horsepower at 150 lb. pressure and running condensing. Changing this to steam consumption per kilowatt-hour would make a water rate of 18.75 lb. per kw.-hr. Under good operation 8 to 10 lb. of water can be evaporated per pound of coal, so the fuel used would be 2 lb. of coal per kilowatt-hour without the auxiliaries. With coal at $3 a ton, this would make about 3 mills per kw.-hr. Auxiliaries would bring up the fuel cost somewhat, but it would be small compared with the main unit. Even better results than this last have been obtained with engines running with high steam pressure and superheated steam exhausting into a condenser.

The usual steam rates for turbines are as follows: 5,000-kw. units, 15 to 16 lb.; 10,000- to 12,000-kw. units, 12 to 13 lb.; 25,000- to 35,000-kw. units, 11 to 11½ lb. per kw.-hr., showing that turbine economy is ahead of reciprocating engines above 10,000 kw. only, and then not by a great amount. I have operated a Diesel engine in a plant where the total fuel cost would run from 3 to 3½ mills per kw.-hr. with fuel oil costing 3.3c. per gal.

Fixed charges are without doubt smaller for a large central station than for a private plant, but the central station has distribution charges to contend with, which the private plant does not have. Where exhaust steam can be utilized, the private plant has a larger advantage; but the amount of exhaust used and the part of the year when it can be utilized will determine whether an expensive and highly economical engine or a cheaper and less economical engine should be used.

Rice Lake, Wis. GROVER SYKES.

What Blisters the Boilers?

I am in charge of a power plant in which there are three horizontal return-tubular boilers, each 72 in. by 16 ft., and they are connected together in one battery, doing 24-hr. service. One boiler is cut out and cleaned every Sunday. They have been in service night and day for eight years. Each of these boilers has been blistered, and in identically the same place. They were free from excessive scale.

One boiler was bagged twice in the same spot; the protrusion was driven back, and we had run about 36 hours when a bag again appeared. This time we cut out the distorted area (a space 14x17 in.) and put in a patch. We then worked the boiler 24 hours, when the patch itself showed a blister like the one we had previously cut out.

These coincidents might be attributed to numerous causes, such as faulty circulation or construction in this one boiler, either of which might have been deemed feasible had not future developments proved them doubtful.

The products of the future developments of which I speak consisted of a series of blisters appearing in the other two boilers. Each blister appeared in the same relative spot in each boiler—within 12 in. of the front end and directly in the middle of the shell over the furnace.

Upon opening these boilers we always find all loose foreign matter deposited upon the spot spoken of as the blistered area. This would seem to indicate the supposed cause of our trouble, but why does this deposit always appear in this same limited space? We feed through the blowoff at the extreme rear end.

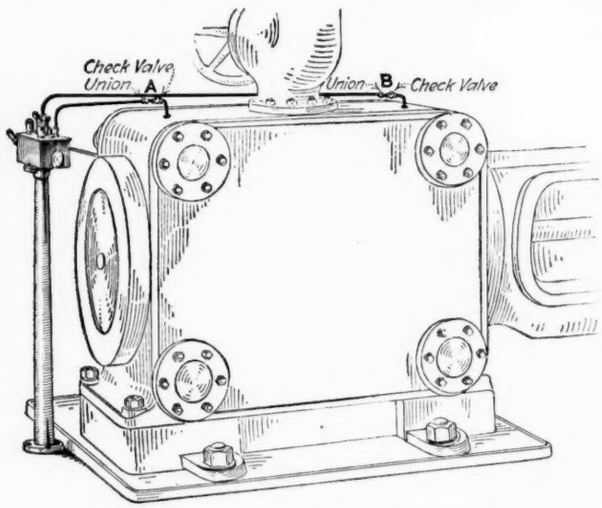
These blisters are very sharply defined, and they are about the depth and size of a common teacup, blending off to an area of about 14x17 in.

I have exhausted my own limited talents, and those of my local friends, and now I would appreciate the opinions of some of the *Power* readers. GEORGE F. WRIGHT.

Sturgeon Bay, Wis.

Lubricator Pump Will Not Feed

The failure of the lubricator to pump properly, according to Mr. Ralston's description in the June 27 issue of *Power,* is probably due to two causes—leaky check valves and excessive clearances in the pump. Undoubtedly the terminal ball check leaks, and most likely the two checks



PIPING OF LUBRICATOR TO ENGINE

between the delivery plunger and the discharge line also. If these valves seated properly, steam could not work back into the oil line.

It is evident from an inspection of the cross-section in Mr. Ralston's letter that this lubricator pumps a mixture of oil and air, the air being carried with the drops from the sight-feed nozzle into the suction of the delivery plunger. When the mixture is compressed sufficiently to open the ball checks against a steam pressure, it is delivered to the discharge line, releasing a corresponding quantity of oil and air at the terminal check. The delivery plunger is in effect both an air compressor and an oil pump.

The passage from the delivery plunger to the discharge line is of very small diameter, so that air will not rise to the surface of the oil. Heating the oil to thin it might help matters, but the trouble is in the excessive length of the discharge passage.

Bubbles of air collect in the plunger clearance and in the space between the delivery ball checks. These bubbles are alternately expanded and compressed with the movement of the delivery plunger. On the upward stroke, when pumping against pressure, instead of oil being drawn in from the sight feed, the trapped air reëxpands, holding the suction ball check directly below the delivery plunger to its seat. As the delivery plunger moves downward, the air is again compressed and the cycle repeated indefinitely. Evidently, the greater the pressure pumped against the worse this condition.

Milwaukee, Wis. W. J. OETTINGER.

I have never known a pump to fail to operate because there was a vacuum on the discharge side. A vacuum on the discharge of a pump will be transmitted through the discharge valves to the pump cylinder and on through the suction valves and would tend to aid the proper operation of the pump.

In the case under discussion the fact that the pump starts working upon breaking the joint in the discharge pipes shows that the auxiliary pump which discharges into the sight-feed glass works properly and that the suction connections are open. It also indicates that the discharge valves are not stuck open. I believe the trouble is due to air binding, which evidently takes place in this case as follows:

On shutting down, the steam in the engine valve chamber condenses so that the pressure falls below atmospheric, and air from the sight-feed chamber flows through the suction and discharge valves of the pump, forcing the oil out of the discharge pipes. On starting, or warming up the engine, steam leaks past the checks *A* and *B,* causing a pressure on the discharge valves of the pump. The pump cylinder and oil passages are full of air, and as the plunger makes its discharge stroke the air is compressed; but because of the large clearances the pressure does not become high enough to open the discharge valves against the pressure caused by the steam leakage. Therefore no air is discharged, but merely expands again on the suction stroke and prevents any oil from entering the cylinder. In other words, the pump is air bound. Breaking the pipe joints relieves the pressure on the discharge valve, and the pump frees itself of air.

If the handwheel of the oil pump is always given several turns before steam is admitted to the engine valve chamber, I believe there will be no trouble. Or a petcock might be placed in the discharge pipes between the oil pump and the checks *A* and *B.* In fact, some makes of force-feed lubricators are regularly furnished with petcocks on the discharge. BURT N. EVERETT.

Jamestown, N. Y.

I have a four-feed oil pump, with double-plunger force feed, that gave the same trouble as described by Mr. Ralston. I overcame the difficulty by bending a ¼-in. pipe to fit tightly around the bottom of the pump box and to carry live steam through the coil to keep the oil hot in the reservoir.

The pipe must be clamped tightly to the reservoir to work satisfactorily. I have never found any reason for the pump's not working without the heating coil, as I have two other lubricators of the same kind that never give any trouble except in very cold weather, when it is necessary to protect them from cold drafts.

Ringwood Manor, N. J. A. A. BLANCHARD.

I believe that Mr. Ralston's trouble is caused by the pump's getting air bound whenever the oil in the reservoir gets so low that air is taken into the suction pipe. The

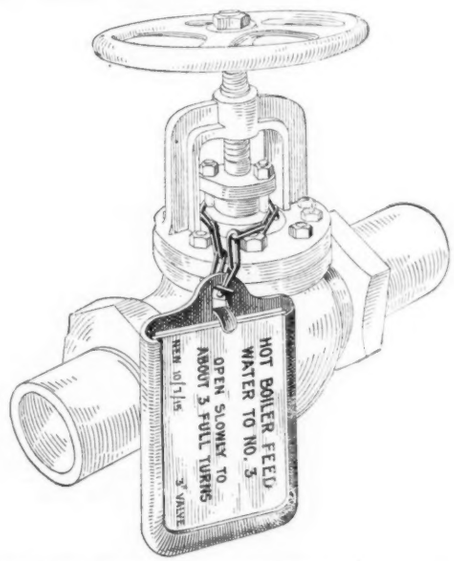
fact that opening the unions on the discharge pipe will cause the pump to work would seem to prove this to be the case.

A cylinder-oil pump should never be allowed to pump the oil down to less than one-half inch above the lower end of the suction pipe; otherwise, it is likely to give trouble. I have operated several pumps of the same design as the one shown by Mr. Ralston and found that if the oil was very hot, say around 200 deg. F., they would not pump the same amount of oil with a given adjustment as with oil at 100 deg. F. This I attributed to the fact that the ball valves allowed the hot oil to slip by more readily than the colder and heavier oil, due to the slow movement of the plungers. C. A. GREEN.

Cleveland, Ohio.

Identification Tag for Valves

The frequent changes of help in our main plant caused much confusion and resulted in many mistakes in operating valves on the maze of small piping, so we purchased a lot of aluminum tags with protected white writing



INFORMATION TAG ATTACHED TO VALVE

spaces—somewhat on the order of the ordinary trunk or baggage tag. These were attached, by light chains, to the bodies of the valves throughout the plant, with an inscription on the tag as to the service of the valve, its size, make, date installed and any special instructions thought necessary. M. A. SALLER.

Philadelphia, Penn.

Overcoming Wattless

The company by which I am employed has a steam plant as auxiliary or stand-by to its main hydro-electric plant. The rapid growth of the city and neighborhood demanded the constant running of the steam plant in order to meet the constantly increasing demand for power. The hydro-electric plant was enlarged until it could easily handle the load itself, but it was then found that the transmission line loss and "wattless" made it still necessary for the steam plant to operate. Two 2,000-kw. turbo-generators were run and made to carry about half-load. A strong field was put on the machines that gave a low leading power factor for the generators and raised the voltage considerably by thus handling a large portion of the wattless.

After running for some months in this manner, steam was shut off the turbines altogether after the machines were cut in on the bus, and a strong field put on the generators. This raised the voltage considerably.

Later, however, this method of operation appeared to be unsatisfactory as far as the turbines were concerned, as they showed signs of vibrating. It was then decided to remove the couplings between the turbines and the generators, permitting the latter to be run as synchronous motors. One of the other turbo-generators in the station was used to bring them up to speed before synchronizing with the system. The procedure was as follows: The station main switch was opened and the turbo-generator was run up to about 500 r.p.m., full speed being 1,800 r.p.m. It was then cut in on the station bus and the field put on and the generator voltage raised to about 800 volts. Then the switch of one of the generators, detached from the turbine, was closed and the machine started to revolve as an induction motor.

Of course the motor pulled a very heavy starting current, so the relay on the machine was short-circuited to prevent the switch tripping. The generators had no relays, but they were put on the synchronous motors so as to kick out in the event of trouble on the system. As the current fell, the field switch was closed and the motor was drawn into synchronism with the generator. The same method was used with the second machine. The turbo-generator was then speeded up, and of course the two motors likewise increased in speed. Then all three machines were synchronized with the hydro-electric plant on the substation 2,300-volt bus. The turbo-generator was then cut off the bus and shut down.

Naturally, this resulted in a big saving in fuel and encouraged the study of further economy. It led to a motor-generator set being installed to take the place of a steam exciter. This was at little expense, as the company had the motor-generator on hand and the steam exciter leads and panel were used for the new machine. The other two steam exciters could singly handle any load called for.

As the oil pump for the machine bearings was driven from the steam end of the turbine shaft, a small duplex pump was used to supply oil to the bearings. These pumps are ordinarily used to pump oil to the bearings on starting the turbine, until it is sufficiently speeded up to supply its own oil. The pump is also used when shutting down a turbine. The only steam necessary now was for the two duplex oil pumps and a pump for delivering water, for oil cooling. A small pipe line was led from these pumps, and steam was shut off the main header after the turbo-generator was taken off the bus. A telltale was fixed on each oil pump so that one could easily see from almost any part of the engine room if the pumps were all right. The result of all this was a further saving in fuel.

It was then suggested that the pumps be done away with, and this led to the decision that the oil be supplied to the bearings by gravity. Two hotwell pumps were idle, since the two turbines were out of commission, and it was decided to use them, one for the oil and the other for the cooling water. A tank was placed to receive the return oil from both machines. A pipe connection was then made

from the tank to one of the hotwell pumps, so that the oil could be pumped into a tank about 20 ft. above the machines. Similarly, the cooling water was handled by the other hotwell pump. These pumps were turbine driven, so the turbines were removed and motors substituted.

Vancouver, B. C. T. J. BURNS.

Pistons Used in Another Compressor

The letter by Jacob Stumpf, in the issue of July 4, page 28, brings to mind an incident where two engineers in neighboring plants, operating duplicate machines, did considerable borrowing and lending of a spare piston in the possession of one of them.

All went well until "diplomatic relations" were suddenly broken off and the borrower found himself in the need of the piston. It took considerable "mediation" on the part of mutual friends to negotiate the loan of the "knockabout" piston for the one time more. A second reserve piston was purchased, however, before it was needed again. J. LEWIS.

New York City.

Steam-Cylinder Lubrication

Having had many years' experience in the use and also in the sale of steam-engine cylinder oil, the following may be of interest to those buying and using it.

Although some writers have belittled the value of the several physical tests and others have attempted to show wherein the lubricating value could be determined only by the gravity, flash, fire, chill and viscosity tests, I believe that the majority of engineers have decided that in all that has been offered for and against the value of laboratory tests there has been little information of any practical value to those operating under the many extreme conditions of the present time.

Some writers have stated that the fire test of a cylinder oil has no bearing on the lubricating value. My experience has taught me the contrary. While it is impossible to burn or flash any oil in a steam cylinder that is nearly void of oxygen, the low flashing-point oils evaporate much quicker and pass off in vapor, leaving the surfaces without oil film. The low fire test denotes a low evaporating-point oil and less lubrication. It is advisable to use an oil higher in its evaporative point than the maximum degree of heat in the metal of the cylinder. It is an aid to lubrication to know the temperature of the metal in the cylinder to be lubricated, in engines running with average steam pressure and of average piston travel of, say, 600 ft. per min. It has been found that the temperature of the metal of the cylinder is from 85 to 100 deg. below that of the steam; with large horizontal engines and high piston speed, the cylinder-metal temperature has been taken at 140 to 160 deg. higher than the temperature of the incoming steam. Without knowing these temperatures, one cannot intelligently decide upon or obtain an oil suitable to meet the requirements. It seems rational to believe that the physical tests are a help in the way of comparison and in aiding to decide on oils to be given a practical test after all the conditions are well understood.

Some of the most prominent writers of late have given no value to the viscosity test. We are taught that the word "viscosity" is a compound meaning the cohesive and adhesive properties of the oil. I would select an oil with the greater adhesive qualities and the less cohesive, meaning the oil that will leave the thickest oil film on the walls of the cylinder with the least oil friction due to cohesion; but the viscosity meters of today, many in kind, give us these two qualities in one, which I believe to be all wrong. The day will soon dawn, no doubt, that will give us an instrument that will indicate the cohesive and adhesive qualities of the oil separately or, in other words, detect in the oil that quality which will cause it to adhere to the hot metal, leaving a film at the extreme heat conditions.

The only positive way to determine the degree of lubrication is to open the cylinder and measure the film of oil and also note all conditions requisite to proper lubrication. The fact that an engine is running smoothly is not always proof that it is well lubricated. Some engines will run and give no signs of distress and be dry, and others will give every known sign of imperfect lubrication while running and when opened, all surfaces will be well covered with oil. Many times the undesirable conditions are overcome by setting right mechanical defects and making proper adjustments.

Cylinder oil dropped on the surface of an inclined piece of cast iron heated to the temperature of the cylinder in which it is to be used, noting the time of travel and evaporation, will give the adhesive properties of the oil much closer than any viscosity meter of the present time. Nevertheless, the viscosity meter is a help.

The subject of cylinder lubrication has been thrown up from all angles to the engineer who is interested, but there are many who are looking for information of more value than that which has been given thus far by the oil chemist or self-interested oil expert, refiner or engine builder. E. B. KELLOGG.

Milwaukee, Wis.

The Exhaust Steam Turbine

Upon reading Mr. Breslav's article on "The Exhaust Steam Turbine," in the June 6 issue, I was forcibly impressed with the importance of studying the conditions under which the exhaust turbine is to operate. In other words, whether prevailing plant conditions favor the installation of straight low-pressure, high- or low-pressure or mixed-pressure turbine.

I was reminded of an electric-power plant—one of three supplying a 240,000-kw. system—where a 7,500-kw. high- or low-pressure turbine was served by three 3,000-kw. reciprocating units exhausting into a common header. Three-phase 2,200 volt alternators connected to the same busbars were driven by the turbine and engines. The high-pressure element had a governor, the low-pressure had none.

Under normal conditions more than sufficient exhaust steam was available for the turbine, the vacuum carried being 29 in. There was no relief valve in the receiver to deliver the superfluous steam, the consequence being that the turbine would speed up and carry, at times, 100,- per cent. overload until the receiver pressure dropped to 15 lb. abs., under which it was designed to operate.

Not having a governor on the low-pressure element, two men had to be stationed at the turbine to hand-operate the low-pressure nozzles, which were distributed around the circumference of the turbine, to maintain the required

receiver pressure, the constancy of which depended on the load variation of the reciprocating units. At a sudden decrease of the load vacuum would be formed in the receiver. This turbine was not provided with a flow valve, causing the reciprocating units to cut off earlier, thereby diminishing the already insufficient exhaust-steam supply.

The high-pressure element was intended for breakdown service exclusively, as exhaust steam for the low-pressure element was available at all times the year round.

The rules laid down for the successful operation of alternators in parallel, in connection with low-pressure turbines, relative to the governing or load-balancing principle, did not hold good in this case, as the output of the turbine and its reciprocating units accounted for but a small percentage of the total load, which was 240,000 kw., and no matter how much load the turbine would take, the influence on the reciprocating units would not be proportional to the requirements for successful operation.

Conditions at this plant obviously called for a straight low-pressure turbine with governor; reducing valve to supply live steam during insufficient exhaust periods; relief valve in the receiver to deliver superabundant exhaust steam; and a flow valve to prevent vacuum creeping back into the receiver.

Far better success was attained with a 3,500-kw. low-pressure turbine operating in connection with four 1,500-hp. reciprocating units, all exhausting in a common header. The accumulator, or regenerator, was successfully employed with this group. The reciprocating engines carried intermittent load, and the regenerator pressure varied between 15 and 20 lb. abs.

I will describe the regenerator briefly for the benefit of those not familiar with it: It is simply a large tank connected into the exhaust steam line supplying the turbine. The tank contains trays inside filled with water. The principle upon which the regenerator operates is that water and steam inclosed in the same vessel are of the same temperature for any given pressure. The temperature of the steam varies in unison with the pressure, and the water contained in the trays, having the same tendency, responds to the temperature changes by absorbing or giving up heat to adjust its temperature to that of the steam. Therefore, when the back pressure in the regenerator rises, owing to an overabundant supply of exhaust steam, the water in the tray absorbs heat due to the higher back pressure, while during the insufficient exhaust periods it gives up the heat previously absorbed.

Sufficient heat was given up in the case of the 3,500-kw. low-pressure turbine previously mentioned to supply the turbine for over five minutes. When the regenerator pressure dropped below 15 lb., abs., a reducing valve supplying live steam to the regenerator became operative.

Haskell, N. J. VICTOR BONN.

Wetting Coal To Reduce Waste

In our plant the boilers are equipped with chain grates, and we had a great deal of trouble making steam fast enough and at the same time keeping the fire from carrying over into the ashpit.

The coal used was culm of a very poor grade containing a large amount of dust. The percentage of droppage through the grates was very high and there would be thin spots in the fire, while on other parts of the grate there would be thick patches. The air would be drawn through where the fire was thin, and where heavy, the coal would be carried over without being burned, resulting in a great deal of combustible in the ash and otherwise bad operating conditions. As we could get no other grade of coal, I began to experiment.

In the first place I tried a spray in the coal hoppers, but found this unsatisfactory for many reasons, the most important of which was that the coal was too wet on entering the furnace and ignition would be slow. This would result in the ignition arch becoming cold and the fire carrying away from the grate, and if the spray was reduced so as not to retard ignition, it was practically useless for the purposes intended—that is, to reduce the droppage and also prevent the small particles of coal being drawn up with the draft before they had time to ignite.

I then changed the sprays to the overhead bunkers so as to wet the coal and get a more uniform dampness, thus giving the bulk of the water time to dry. This was an improvement, though still unsatisfactory, as it was difficult to regulate the sprays to get the desired effect, the coal landing on the grate in wet and dry streaks a great deal of the time. So I then put the spray in the coal chute where the coal is delivered to the conveyor, and this was found to be entirely satisfactory. The coal received a uniform shower as it was delivered to the buckets, and this could be regulated so that the fuel was damp all through and it also gave the bulk of the water time to drip out or dry up, leaving the coal damp enough. The ignition was not retarded very much, and it was easy to keep the arches hot; the droppage was reduced two-thirds, and the fires burned off nicely, none being carried over. The amount of ashes was also reduced one-third, and it was easier work to get steam with less coal.

The objection may be raised that the conveyor buckets and bunker would suffer on account of water, but our bunker does not seem to be affected as there is enough heat present to dry the coal that lies next to it. The bunker is concrete-lined, and there is no moisture getting to the plate as far as we can see. The coal-conveyor buckets undoubtedly suffer to some extent, but the saving on fuel and generally improved conditions more than offset this effect.

I do not wish to be understood as advocating this practice generally, but in some cases such as stated it is worth while. J. A. MCGILLIVRAY.

Trenton, N. S., Canada.

Gages for Steam Traps

I have fitted several float-type steam traps with gage-cocks in place of glasses and find that they are always better except where the trap operates under a vacuum.

A trap is often located where the breaking of the gage-glass will do damage, and after this happens once or twice the gage is likely to be allowed to remain closed, leaving no indicator at all, and some are even made without a gage of any kind. With some types it is difficult to tell where the water level should be, and the glass will often show considerable water even when steam is escaping. Sometimes the manufacturer marks the water level, but the mark is hidden when the covering is applied.

Traps are sometimes installed so that they can be discharged into the open, and when used with high-pressure

steam, some of the water will turn into steam when released, and it is often difficult to tell by this method whether the trap is wasting steam or not.

A gage-cock placed just above the outlet valve and another at the top of the trap will tell whether the trap is working correctly.

Separators require only one gage-cock just high enough to avoid the water that may be at the bottom, otherwise it will show water when first opened—the bottom opening for the glass gage for this reason is not suitable. When so located, it may be opened as often as desired with no inconvenience, as only dry steam will be discharged when the separator is properly drained.

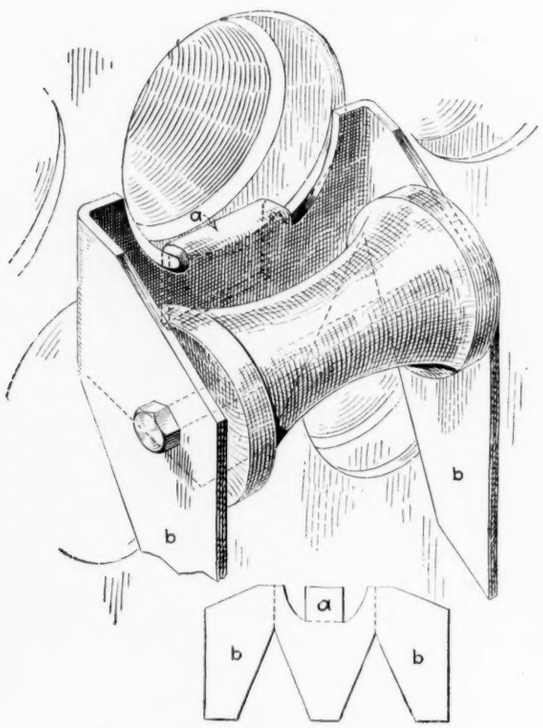
It will pay to use good gage-cocks instead of cheap pet-cocks. The type that depends on the pressure to hold it closed is apt to drop open at low pressures and let out considerable water before being closed again.

Buck Hill Falls, Penn. WALTER S. GRISCOM.

Protecting Tube-Cleaner Hose

The illustration shows a device to eliminate the wear and tear on hose supplying air, steam or water to cleaners used for removing scale from the tubes of water-tube boilers.

It is often necessary to draw the hose to which the cleaner is attached back and forth several times, and



ROLLER IN POSITION ON HEADER

each time it comes in contact with the sharp edges of the handhole, soon wearing the wire or plies of the hose and causing a leak or blowout.

To overcome this a simple device was made by cutting and drilling a sheet of ⅛-in. flat iron and bending the throat piece *a* down so as to form a tongue to fit over the edge of the handhole opposite the tube to be cleaned. The two side pieces *b* were bent at the dotted lines to form the sides, for holding a hardwood roller about 5 in. long, turned up on a lathe, and turning on a ⅜-in. bolt put through the roller and iron side supports. The roller revolves backward and forward with the motion of the hose. WAYNE G. BROOKINS.

Lyons, N. Y.

Provision for Expansion

The clock movement on a recording gage was taken to a local clockmaker to have some broken parts replaced. When returned it was running in good shape, and it was installed right near the boiler front, but when set up, it became sluggish in action and soon stopped altogether.

It was taken down one evening to be sent back to the repairman, but in the morning, much to our surprise, it was ticking away merrily on my desk and continued to do so all day; so we decided to give it another try, but the result was the same as before. After again exhausting our patience in coaxing it to go, we took it down and, as in the previous case, it was ticking away in the morning. The clockman pronounced the mechanism O. K., but when he learned that the clock was subjected to a high temperature, he said he saw at once what was wrong. The new pinions and gears which he supplied were a tight fit, and when heated, the expansion caused enough friction to stall the mechanism, but when again cooled down, as after lying overnight on my desk, its action was normal.

New gears which allowed sufficient clearance to take care of the expansion cured the trouble.

Philadelphia, Penn. M. A. SALLER.

CO_2 Recorder in Small Plants

I have so improved combustion in our plant—one of 200 hp. in boilers—by the aid of an Orsat, though I had supposed the combustion to have been very good, that I am wondering if it would be worth while to install a CO_2 recorder in a plant so small.

Where is the best place to locate the recorder—on the boiler fronts or near them, or in the chief engineer's office? I would like to read discussion of these questions in *Power*. J. PRIEFER.

Brooklyn, N. Y.

Graphite for Cylinder Lubrication

A casual reading of your comment under the head of "Lubricants and Lubrication," page 923, June 27 issue of *Power*, gives the impression that it would be well not to use graphite in cylinders because of its tendency to fill the pores of the metal and thus make it more difficult to keep oil on the surfaces.

While this is true, we all know that it is a good rather than a bad feature, because very little oil should be used in cylinders anyway—only enough to distribute the flakes of graphite. The plants that use graphite intelligently in connection with oil are the ones that have the least trouble. L. W. BROOKS,

Joseph Dixon Crucible Co.

Jersey City, N. J.

Three Thousand Volt Direct Current Substations

SYNOPSIS—An outline of the power equipment for the Chicago, Milwaukee & St. Paul electrification, in which some of the operating characteristics are described.

The approaching completion by the General Electric Co. of the electrification of 440 miles of mountainous railway of the Chicago, Milwaukee & St. Paul Railway Co., from Harlowton, Mont., to Avery, Idaho, may well be considered the logical result of electricity coming into its own. During the month of April the electrified zone was extended to include about 220 miles of track and by November, 1916, it is expected to have the entire 440 miles operated by electricity. This will be one of the most extensive steam-railway electrifications in the world.

The scheme of electrification includes the generation of electricity from the several water-power plants of the Montana Power Co., transmission at 100,000 volts three-phase 60 cycles, conversion in substations to 3,000 volts direct current and overhead construction to the locomotives.

Power is taken from the transmission lines to fourteen substations distributed along the right-of-way and stepped down through oil-cooled transformers to 2,300 volts. The transformers in one of the substations are shown in Fig. 3, the high-tension oil switches being to the right of the illustration with the disconnecting switches and insulators above them.

The 2,300-volt alternating current is converted into 3,000-volt direct current by means of motor-generator sets, which comprise a 2,300-volt synchronous motor and two 1,500-volt direct-current generators directly connected to each end of the motor shaft and connected permanently in series for 3,000 volts for the locomotives. The fields of the synchronous motor and the shunt-field coils of the direct-current generators are separately excited by two small generators, one directly connected to each end of the motor-generator shaft—one for the fields of the synchronous motor and the other for the direct-current generators. The direct-current generators are compound-wound, will maintain constant voltage up to 50 per cent. overload and have a momentary capacity up to three times their normal rating. To insure good commutation the generators are equipped with interpoles, and compensating windings in the pole faces. The synchronous motors are designed to give automatic correction of power factor due to the load taken by the motor-generator set. No correction is made in the voltage or power factor due to outside causes. The power factor is governed by changing the excitation on the synchronous-motor field exciter by means of a series field which is excited from the direct-current generator. The voltage and consequently the field current furnished by this exciter rise with the load and thus regulate the power factor of the set. On light loads the power factor is lagging; at approximately half-load it is 100 per cent.; at higher loads the power factor is leading.

Fig. 1 shows the interior of one of the substations containing three motor-generator sets. The synchronous motor, one of the 1,500-volt generators and one exciter are clearly shown. Two features about the 1,500-volt generator stand out very clearly that are not characteristic of most direct-current machines; namely, the flash-board back of the brushes to protect the windings in case of a flashover at the brushes, and the rectangular ventilating duct mounted on the back end of the generator frame. In the 14 substations on the system there are installed 32 of these motor-generator sets; nine of them are 1,500 kw. each and twenty-three 2,000 kw. each, making a total capacity of 59,500 kw. One of the substation switchboards for controlling three 1,500-kw. motor-generator sets is shown in Fig. 2. The circuit-breakers are mounted above the board. Note the large barriers between them to confine the arc incident to opening the 3,000-volt circuit.

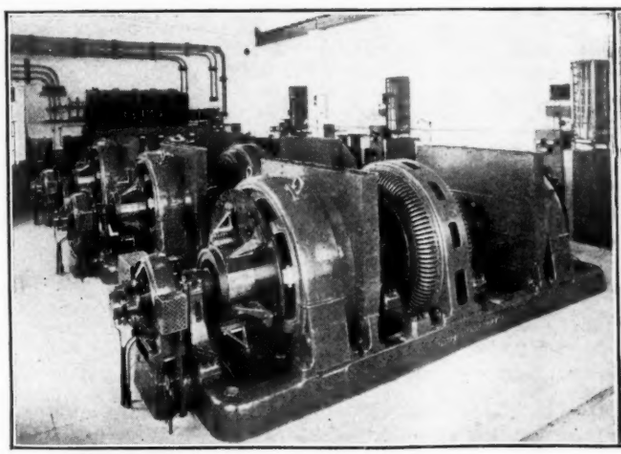


FIG. 1. SHOWS THE INTERIOR OF A SUBSTATION CONTAINING THREE MOTOR-GENERATOR SETS

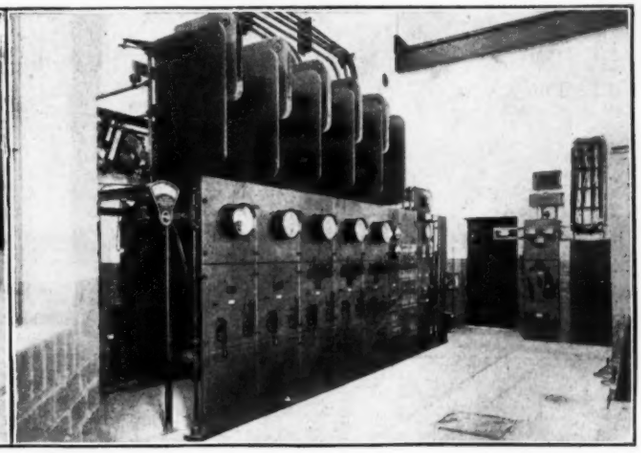


FIG. 2. SHOWS SWITCHBOARD FOR CONTROLLING THREE 1,500-VOLT MOTOR-GENERATOR SETS

Another notable feature about this installation is regeneration, or the recovery of energy from the locomotive motors on the descending grades, by reversing the function of the motors. The energy of a heavy freight train running at 17 mi. per hr. on a 2 per cent. grade amounts to about 3,500 kw. With regenerative breaking the motors

become generators and absorb the energy of the descending train, which is converted into electricity and is returned to the trolley for the use of other trains. In case there are no trains between the substations to absorb the power generated by the descending train, this power passes through the substation machinery, is converted from direct to alternating current and fed back into the 100,000-volt distributing system connecting all substations. The percentage of energy that is returned to the high-tension transmission system by regeneration is approximately 12 to 15 per cent. of the amount taken by the locomotives for the 220 miles now in operation. This figure is approximate as only half of the electrification is as yet in operation and no accurate tests have been made. The power company's lines are so extensive and the load so diversified that any surplus power returned by regenerating locomotives can readily be absorbed by the system; credit is given for all energy returned to the high-tension system.

Utmost precautions were taken by the railway company in making plans for this electrification to insure a reliable source of power. The Montana Power Co., with whom the contract was closed for electric power, operates a most extensive network of transmission lines cov-

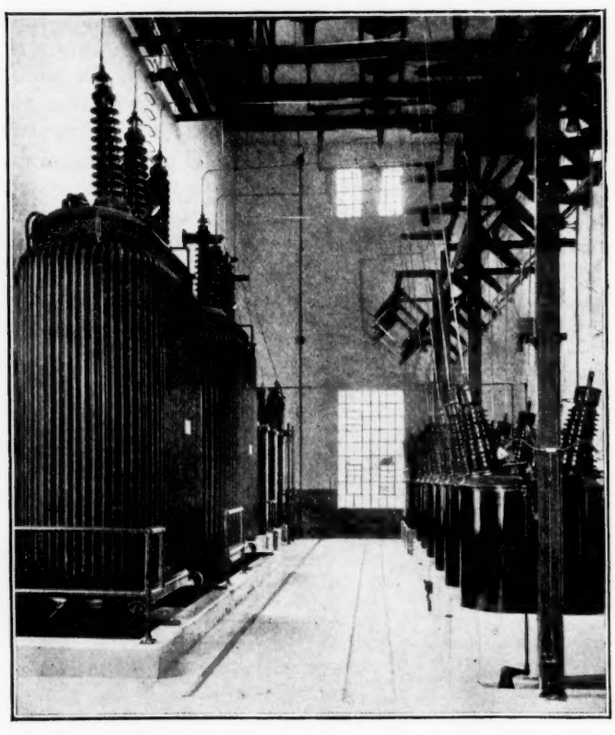


FIG. 3. SHOWS 100,000-VOLT TRANSFORMERS AND OIL SWITCHES IN ONE SUBSTATION

ering a large part of Montana. The line is tapped into the railway system at seven different points where the power is most needed. The railway company's transmission line extends the entire length of the system. With this completely interconnected transmission system, each substation may be fed from either direction and also at the tie-in points from a third source of power, therefore the possibilities of power failure are very remote.

It was estimated that the cost of this electrification would be about $12,000,000, and with the work more than half completed there is every reason to believe that the cost of construction will come inside this estimate.

Economy Test of Lentz Engine and Boiler

By G. C. Long

A test was conducted May 5 at the plant of the Lakeland Phosphate Co., Lakeland, Fla., to determine the efficiency and economy of a Lentz cross-compound engine and a vertical water-tube boiler, both made by the Erie City Iron Works, Erie, Penn.

The unit (engine and boiler) was sold under a guarantee to deliver one kilowatt-hour at the generator terminals per 1¾ lb. of coal containing not less than 14,500 B.t.u. as consumed in the furnace, a vacuum of 26 in. and a feed-water temperature of 206 deg. F. to be maintained by the purchaser.

The 25&42x30-in. engine is of the single-piece cylinder-construction type of poppet-valve engine, having a rating of 1,500 hp. and a steam consumption of 9.5 lb. per hp. per hr., with a vacuum of 26 in. and steam superheated 200 deg. and at a gage pressure of 210 lb. It is direct-connected to an alternating-current generator rated at 750 kw. with 82 per cent. power factor.

The boiler is of the vertical-type construction with a heating surface of 2,724 sq.ft. and an available grate area of 60 sq.ft., and is equipped with a superheater.

Owing to a scarcity of circulating water for the condenser, only 25 in. of vacuum was obtained, necessitating an allowance of 1.45 per cent. in the equivalent coal consumption and an additional allowance for the feed-water temperature not being so high as that stipulated in the requirements; the allowance in this case was 2.9 per cent.

RESULTS OF THREE-HOUR TEST

	First Hour	Second Hour	Third Hour
Coal burned	1,292.5 lb.	1,300 lb.	1,425 lb.
Kilowatt output	740	760	720
Coal burned per kilowatt-hour	1.74 lb.	1.71 lb.	1.98 lb.
Feed-water temperature	170.4 deg.	180.16 deg.	180.66 deg.
Steam pressure gage	210 lb.	205.6 lb.	199 lb.
Vacuum	25 in.	25 in.	25 in.
Superheat at high pressure valve bonnet	151 deg.	157.9 deg.	158 deg.
Draft	0.27 in.	0.27 in.	0.27 in.

SUMMARY OF THREE-HOUR TEST

Coal burned per hour, 1,339 lb.
Average kilowatt output per hour, 740.
Average feed-water temperature, 177 deg. F.
Average vacuum, 25 in.
Average steam pressure, 204.8 lb. gage.
Average superheat, 155.6 deg. F.
Average coal burned per kilowatt per hour, 1.809 lb.
Average coal burned per hour per kilowatt, corrected as to feed-water temperature and vacuum, 1.73 lb.
Correction for feed-water temperature, 2.9 per cent.
Correction as to vacuum, 1.45 per cent.
Average draft, 0.27 in. of water.
Average CO_2 = 12.08 per cent.
Average CO = 0.83 per cent.
Average O = 6.25 per cent.
The constant load on the generator was supplied by a variable water resistance.
The boiler was stoked by hand.

There are also three vertical boilers of the same size and rating as the tested boiler, operated with oil fuel at an oil consumption of approximately 0.25 gal. per kw.-hr., using fuel oil of 19,190 B.t.u. per lb., and an equivalent evaporation of approximately 11.2 lb. of water per pound of oil.

The Industrial Board of the Department of Labor and Industry of Pennsylvania has decided in the interest of co-operation and uniformity to accept inspectors holding certificates of competency as boiler inspectors from Massachusetts or Ohio, without any further examination, provided they are in good standing with the authorities of either of the states mentioned. It will be necessary, however, for their employers to advise this department of their names, date of issue and number of certificate.

Inquiries of General Interest

Tube Spacing of Horizontal Return-Tube Boilers—What should be the least spacing of tubes for horizontal cylindrical boilers? R. H. M.

The vertical and horizontal spaces between tubes should not be less than ¾ in. in the clear and the horizontal preferably not less than 1 in. When a vertical circulation space is left at the center of the tube sheet, it should be at least 2 in.

Ratio of Expansion—What is meant by the ratio of expansion in an engine? J. L.

The ratio of expansion of the steam used in an engine is the quotient derived from dividing the final volume of steam found in the cylinder by the initial volume. By initial volume is meant the volume of steam admitted to the cylinder up to the point of cutoff plus the clearance volume, and by final volume is meant the volume displaced by the stroke of the piston plus the clearance volume.

Discharge Pressure of Injector—Can an injector, when supplied with steam from a boiler that is under 100 lb. pressure, be used for feeding another boiler under a higher pressure? C. R.

Nearly all feed-water injectors are capable of discharging against a pressure considerably higher than the pressure of steam used for their operation, depending on the lift of the suction water and its temperature. With the water not over 80 deg. F., many injectors will force against a pressure 75 lb. per sq.in. higher than that of the steam supplied.

Hydrostatic Pressure Test of Boiler—What should be the cold-water test pressure of a boiler for a working pressure of 110 lb. per sq.in.? J. C.

It is customary to apply a hydrostatic test pressure of one and one-half times the maximum allowable working pressure, and for an allowable working pressure of 110 lb. the test pressure would be $110 \times 1.5 = 165$ lb. per sq.in.

In testing, the hydrostatic pressure should be under proper control, so the required test pressure will not be exceeded by more than 6 per cent.

Detection of Leaky Slide Valve and Piston—How can leakage of steam by a slide valve or a piston be detected? B. R. G.

Leakage of a slide valve is usually indicated by the character of the exhaust. If the valve is tight, the exhaust will be sharp and intermittent, but if leaky, the discharge will be continuous. Another method is to place the engine so the valve will cover both steam ports, block the engine from turning and open the throttle valve. If the valve is tight, no steam will escape from the exhaust pipe or cylinder pet-cocks. A leaky piston is best detected by removing the cylinder head and, after blocking the wheel or crosshead with the piston at about one-half stroke from the crank end, opening the throttle valve and observing whether steam blows past the piston.

Equalization of Compression on Indicator Diagram—With a D slide valve, on which end of an engine cylinder must the exhaust have greater inside lap so as to equalize the compression shown on an indicator diagram? W. E. C.

On account of the angularity of the connecting-rod, a given fractional part of the stroke of the piston from the head end of the cylinder is accompanied by less angular displacement of the crank and eccentric than for the stroke from the crank end. Hence, to equalize the compression shown on an indicator diagram, there must be more inside lap on the exhaust of the crank end, so that the exhaust will be closed for less angular rotation of the crank and eccentric during the stroke of the piston from the head end of the cylinder than from the crank end.

Surplus Heat Should Be Returned as Condensate—Can steam after having passed through the coils of a sterilizer be returned direct to the boiler? M. J.

When steam is deprived of part of its heat its pressure is reduced and there is no practicable method of returning it in the form of vapor to the boiler in which it was generated. The operation of restoring the pressure for returning the waste steam to the boiler either by mechanical compression or by reheating would be attended by consumption of power and other heat losses very considerably in excess of the amount of heat first abstracted. The most practical method of recovery of the heat in the steam that is not utilized by the sterilizers would be to employ a closed system, with a return trap, or pump and receiver, for returning the condensate to the boiler.

Brake Power of Motor—In a prony-brake test of a motor the speed of the brake wheel was 520 r.p.m.; the horizontal length of brake arm from center of brake pulley to point of suspension of the weight was 42 in.; the weight of brake arm, taken at the point where the poised weight was suspended, was 27 lb.; and the weight supported was 34 lb. What number of brake horsepower was developed? W. L. N.

The power developed is given by the formula:

$$P = \frac{L \times 2\pi \times N \times W}{33{,}000}$$

Where

P = Brake horsepower;
L = Length of brake arm in feet;
$2\pi = 2 \times 3.1416$;
N = R.p.m. of brake wheel;
W = Net weight balanced, in pounds.

Substituting the given values,

$$P = \frac{(42 \div 12) \times (2 \times 3.1416) \times 520 \times (27 + 34)}{33{,}000} = 21.13 \text{ hp.}$$

Feed Pumps for Different Boiler Pressures—Where six boilers are operated at 80 lb. pressure and two are operated at 125 lb. each, requiring the same amount of feed water per hour, would it be more economical to operate one feed pump for the low-pressure and one for the high-pressure boilers or one feed pump capable of feeding all boilers? B. H. C.

Assuming that in either case the pumps would operate continuously with the same efficiency and that the steam consumption is directly as the volume of water and the discharge pressure, then the relative economy of operating two pumps or one would be as $[(80 \times 6) + (125 \times 2)]$ to (125×8), or as 73 for operation of separate pumps to 100 for operation of only the higher-pressure pump. To make the cost of operation the same for either case, the efficiency of the high-pressure pump would have to be about 1½ times the efficiency of the other. But considering greater first cost of separate pumps, heaters and pump connections and less convenience of operation, for most plants it would be found more practical to do all the boiler feeding with a pump adapted to the higher pressure.

To Reverse D Slide-Valve Engine—How can the eccentric of a D slide-valve engine be set on the shaft so as to reverse the engine and obtain admission and other events at the same points of the stroke? G. H. A.

The engine will be reversed, and all events will occur at the same relative points of the stroke, if the eccentric is rotated on the shaft until its center lies on the opposite side of the shaft and is set at the same angle ahead of the crank in the direction of rotation. To find the new position for the eccentric, make marks on the valve stem corresponding with the end of the valve-stem stuffing-box, when the valve stem is at each end of its travel, and mark a point on the valve stem midway between those marks. Then turn the engine wheel in the old direction of motion until the middle mark comes opposite to the end of the valve-rod stuffing-box. The valve now will be in the middle of its travel, and the angle through which the wheel must then be turned to place the crank on the nearer dead-center will be equal to the angular advance of the eccentric. Next make a mark on the crosshead corresponding with a mark on the guide and then turn the wheel in the old direction of rotation so the crank passes over the nearer dead-center, continuing the rotation of the wheel until the mark previously made on the crosshead again corresponds with the mark on the guide. With the crosshead held at this point, loosen the eccentric from the shaft, rotate it until its center line lies on the opposite side of the shaft and secure it permanently in such a position as to again bring the valve stem to the middle of its travel.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Firing Soft Coal Under Naval Boilers*

By William L. De Baufre

SYNOPSIS—Tells what methods are used in the United States Navy to most successfully burn coal under boilers.

Coal for naval use consists of from 90 to 95 per cent. of combustible matter and from 10 to 5 per cent. of ash.

The fuel bed does not burn and sink in uniform layers. It is not of uniform porosity, and the greater quantity of air which naturally flows through a place of low resistance causes more rapid combustion there than in the denser portions of the bed, thus producing a "hole" in the fire. Few if any firemen are so skilled that they can keep these "holes" filled up and the fuel bed even simply by throwing the coal in the proper places with a shovel. It is therefore necessary to use a light hoe or rake to level the fire.

Also, with marine boilers, the yellow flames so fill the combustion space that it is practically impossible for the fireman to see the condition of the fire on the back half of the grate. It is therefore necessary for him to run a light hoe over the back of the fire to determine its thickness as a guide for coaling, in addition to filling up whatever "holes" may be present. However, the fires should not be disturbed more than necessary to accomplish the desired objects, and the more skillful a fireman is with the shovel the less will he need to disturb the fuel bed with a hoe or rake.

Most coals used in the naval service tend to cake and thus form a solid crust over the fire. Cracks start in this crust through which the air passes, and crevices are formed by the crust burning at the edges of these cracks. Such crusts should not be allowed to form to any extent. While they can be largely prevented by firing smaller quantities of coal at more frequent intervals, they should also be kept broken up by the use of a light hoe.

The hoe is likewise necessary when the coking method of firing is adopted. The coal is thrown onto the front part of the grate only and the volatile matter allowed to distill off, when the resulting coke is pushed back with the hoe over the fuel bed. This method of firing is not considered as conducive to good results as the alternate or consecutive spreading method; that is, spreading the coal over the entire fire in the furnace doors alternately or consecutively. (The word alternate applies, of course, to two doors only, and the word consecutive is proposed for the same method applied to a furnace with three or four doors.)

USE OF HOE AND SHOVEL NECESSARY

Skill in the use of the shovel supplemented with the light hoe or rake will keep the top of the fuel bed in proper condition. Additional tools are necessary for the bottom of the fuel bed, especially with stationary grates as used in the Navy.

There are very few coals with an ash-fusing temperature so high that no clinkers are formed.

The ashes that fall between the grate bars into the ashpit contain combustible matter in addition to the ash. The ash that remains above the grate, whether it fuses into clinkers or not, shuts off the air supply to the combustible above. A fire tool must therefore be employed to work this ash through the grate. If a hard clinker is formed which tends to stick to the grate, a sharp-pointed slice bar is required to pry it loose and break it up. But if the clinker formed is very friable or if simply ashes accumulate, a better tool for the purpose is a bar with a flat chisel-shaped end. A pricker bar may also be conveniently used under these conditions.

Neither the slice bar nor the pricker bar should be used indiscriminately, but should be moved back and forth over the grate where the ash or clinker is located just sufficiently to work it into the ashpit. The location of the accumulation of clinker or ash is indicated by the shadows or dark spots on the floor of the ash pan. Its removal is shown by the brightening of the dark spots. The brightening, however, will generally not occur as soon as the ash or clinker is removed, because the combustible above has been deadened by lack of air. Too much working of the slice bar will increase the loss of combustible in the ashes. Also, the fireman should not bear down on the slice bar to break up the fuel bed, as this will mix unburned coal with the ash and generally cause an excessive amount of clinker. Rocking grates are provided in stationary and locomotive practice to accomplish the same purpose of working the ash and clinker through the grate.

But even with the use of the slice bar, there are few coals in the burning of which the ash can all be worked through the grate. Clinkers will accumulate; and while they may be kept broken in many cases by the use of the slice bar, they must eventually be removed through the furnace door. The cleaning intervals adopted will depend upon the quantity and character of the clinkers, the variation of the load upon the boiler, the sequence of watches of the firemen, and the necessary routine of removing ashes from the ship.

For a thorough cleaning, the fire within the furnace door selected should be allowed to burn down slightly. At the time of cleaning, the combustible in the top of the fuel bed is winged over onto the fire at either side, using a hoe and a slice or special flat bar. The bottom of the fuel bed containing the clinkers is then hauled out of the furnace with a heavy hoe. The fire is now winged back onto the bare grates, leveled and built up to standard thickness. Before cleaning, it is preferable to build up slightly the thickness of the fuel bed in the doors that are not cleaned. Also, under steady load conditions, it is better to clean the fire successively at regular periods unless the routine of the removal of clinkers and ashes prevents. Troublesome clinkers may be removed between the regular cleaning periods by using the familiar tool called the "devil's claw."

FORMATION OF CLINKERS

In working the top and bottom of the fuel bed it has been emphasized that the fuel bed as a whole should not be disturbed more than necessary. This is done to prevent as far as possible the formation of clinkers. Clinkers are due to the fusing together of particles of ash. The temperature at which the ash fuses depends mainly upon the constitution of the ash in the coal. When the fusing temperature is high, there is no trouble with clinkers, no matter how the fires are worked. With a low fusing point it is impossible to prevent the formation of troublesome clinkers, even with the most careful firing. But there are coals having a moderate fusing temperature of the ash which will give satisfactory results by careful firing. When the fuel bed is not disturbed, the ash accumulates only in the lower portion where the temperature is lower than in the upper portion of the fire. Also, in the lower portion of the fuel bed there is an oxidizing atmosphere, while in certain upper portions there is a partially reducing atmosphere, and the fusing temperature of ash is less in a partially reducing than in an oxidizing atmosphere.

Thick fires especially produce an atmosphere conducive to the formation of clinkers. The fires should therefore be carried as thin as is consistent with the draft and with good combustion, as measured by the constitution of the flue gases. The better the condition in which the fires are maintained, the thinner can they be carried with good combustion with the same draft.

CONDITIONS AFFECTING DRAFT

Draft is the difference in pressure between the air in the boiler room and the flue gases at the point considered. Furnace draft, for example, is the difference between boiler-room pressure and the pressure of the furnace gases just above the fire. Stack draft is the difference in pressure between the boiler room and the flue gases at the base of the stack. The difference between the furnace draft and the stack draft is therefore the difference in pressure between the gases in the furnace and at the base of the stack. It is evident that this difference is equal to the frictional resistance overcome in forcing the gases through the passes and between the tubes of a water-tube boiler, for example. The furnace draft is equal to the frictional resistance encountered in forcing the air through the fuel bed. The former resistance will vary with the volume of the flue gases, but the latter will also be affected by the condition of the fuel bed.

To force the same quantity of air through the fuel bed a greater resistance is encountered if the fuel bed is thick, if a crust of unburnt coal is formed over the top, if ashes or clinkers clog up the grate at the bottom, or if the sizes of the coal particles in the middle of the fuel bed are such as to pack closely together into a dense mass. The last-mentioned cause of increased resistance depends only upon the character of the coal, but the first three are largely within the control of the fireman. Looked at in another way, if the fireman allows the coal to crust over the top, or if he allows clinkers and ashes to

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accumulate at the bottom, or if he allows the fire to become too thick, the air supply will be cut down unless "holes" are allowed to form in the fuel bed. These assumptions are based upon constant draft conditions; if the draft is raised the air quantity is increased, with the other conditions remaining constant.

In passing through the ashpit the air is somewhat heated by radiation. It is further heated in passing over the grate bars, which it thus keeps from being overheated. In the fuel bed it is still further heated until a sufficient temperature is reached to cause the oxygen to combine with the hydrogen in the fuel to form superheated steam (H_2O); with the sulphur to form sulphur dioxide (SO_2); and with the carbon to form carbon monoxide (CO), which then burns to carbon dioxide (CO_2). The nitrogen (N_2) of the air passes through unaffected, and oxygen (O_2) is found in the flue gases because an excess quantity of air over that theoretically required for combustion is always admitted.

COMPOSITION OF THE FLUE GASES

Hence the flue gases contain superheated steam or moisture (H_2O), sulphur dioxide (SO_2), carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2) and nitrogen (N_2). There may also be present particles of partly burned coal which will be deposited on the tubes and baffles as soot or carried out the stack as smoke. The flue gases may contain unburned hydrocarbons distilled from the coal if the air supply and temperature are not sufficient to cause their combustion.

The presence of superheated steam (H_2O) in the flue gases represents a loss. The loss is equal to the heat required to raise the temperature of the moisture in the air to the temperature in the stack, and the heat necessary to evaporate and superheat to stack temperature the moisture in the coal, that formed from the hydrogen present, the water added to the coal, and that put into the ashpit. The water added to the coal and the water put into the ashpit are the only items under the control of the fireman. Water may be added to coal to allay the dust in the fireroom or to reduce the loss of fine coal up the stack. No data are at hand to show the reduction in soot and smoke by adding water to the coal. Water should not be used in the ashpit unless it is necessary to keep the grate bars cool, to prevent troublesome warping of the ash pan, or to reduce clinker formation. Clinkers are sometimes reduced by blowing steam into the ashpit.

The amount of sulphur dioxide (SO_2) present simply depends upon the quantity of sulphur in the coal, and is small in coals for naval use. Sometimes a portion of the sulphur present remains in the ashes or clinkers as sulphur trioxide (SO_3).

The presence of unburned hydrocarbons depends partly upon the volume of the combustion space available, the manner of firing, and the proportion of volatile matter in the coal. If the combustion space is small, the hot gases containing unconsumed hydrocarbons are liable to reach the comparatively cold surfaces of the boiler and be cooled below the ignition temperature before they are completely burned. Also, if large quantities of coal are fired at a time, the large volumes of hydrocarbons distilled off are liable to lack sufficient air for combustion. If the coal contains a large percentage of volatile matter, the same condition is liable to obtain with careful firing. This fact is one reason why high-volatile coals are not suited for combustion in marine boilers where the combustion space is necessarily limited. From the fireman's standpoint coal should be fired in small quantities to prevent a loss due to unburned hydrocarbons. If necessary to increase the thickness of the fire, this should be done gradually and not by throwing a large quantity of fresh coal on the grate at one time.

DETERMINING CARBON DIOXIDE

With medium or low-volatile coal and fair firing, hydrocarbons are rarely present in the flue gases, even with the limited combustion space in marine boilers. It is therefore customary to omit their determination from the analyses of the flue gases. Neither the percentage of moisture (superheated steam) nor of sulphur dioxide is determined, but the analysis is limited to the measurement of the proportions by volume of carbon dioxide (CO_2), carbon monoxide (CO) and oxygen (O_2) present, the nitrogen (N_2) being found by difference. For routine conditions of service it is necessary to determine the percentage of CO_2 only as a guide to the condition of the fire. Recording CO_2 machines are built for this purpose.

The four quantities, CO_2, CO, O_2 and N_2, are closely related to the air supply. By perfect combustion with just the right quantity of air there would be in the flue gases about 20 per cent. of CO_2 and 80 per cent. of N_2 by volume. With air in excess of the theoretical quantity, O_2 is also present, the N_2 remaining approximately 80 per cent. of gas and the CO_2 and O_2 together being equal to about 20 per cent. The percentage of O_2 is an indication of the amount of excess air. Unless sufficient excess air is admitted, the flue gases will contain CO. The presence of CO represents a loss due to incomplete combustion, but the presence of O_2 with the correspondingly lower proportion of CO_2 also represents a loss due to excess air. When one loss is increased the other is decreased, and the combustion conditions should be adjusted until the sum of these two losses is a minimum. From experience at the Naval Engineering Experiment Station, it is believed that for naval boilers the minimum loss will correspond to a CO_2 percentage between 12 and 12.5 per cent.

The analysis of the flue gases is generally made at the base of the stack. Therefore, part of the excess air present is due to infiltration through the boiler casing. Before the efficiency of the combustion can be properly judged, care must be taken to insure that the casing is air-tight. Excess air is also admitted when the furnace doors are opened for coaling or leveling; hence these operations should be done quickly. However, undue haste should not prevent proper placing of the coal, and leveling for "holes" left in the fire during the intervals between the above operations will admit more excess air than the doors open for a few additional seconds.

The most economical results are obtained when the whole fuel bed is kept in a uniform condition. Then the desired percentages of carbon monoxide and oxygen and the corresponding percentage of carbon dioxide (CO_2) which has been found best by trial are kept constant by regulating the thickness of the fuel bed. If the CO_2 becomes low, it means that too much excess air is passing through the fuel bed, which is therefore too thin. The thickness should be built up gradually. If the fuel bed is too thick it should be allowed to burn down somewhat by firing slightly less coal until the desired CO_2 percentage is obtained.

The proper thickness will be between 4 and 8 in., depending upon the draft required to burn the requisite number of pounds of coal per square foot of grate surface per hour and also upon the clinkering properties of the coal. A clinkering coal should be burned with a thinner fire than a good coal. It may be impossible with a clinkering coal to attain a CO_2 percentage of 12 per cent. because the layer of clinker over the grate will shut off the flow of air through the fuel bed, and the consequent greater draft in the furnace will result in increased air leakage through fire doors and setting.

REGULATION OF STACK DRAFT

The stack draft should be regulated according to the load on the boiler. Regulation by the damper is better than regulation by opening or closing the ashpit doors because less excess air is liable to be drawn through the boiler casing by the former than by the latter method. When the load suddenly increases, the combustion is often intensified by the firemen cracking the fuel bed by lifting it slightly with the slice bar. With a coal that tends to clinker, this should be resorted to only in the last extremity and should be carefully done to prevent breaking up of the fire.

The furnace draft may be used as a guide in working the fires. If its value be noted for a given stack draft when the fires are in their normal condition, a rise in the furnace draft will denote an increase of the resistance through the fuel bed, and a drop will denote a decrease. The increase may be due to the fuel bed becoming thicker or clogged with ashes and clinkers at the bottom or covered with a coal crust at the top in case the coal cakes. The decrease will be due either to a thin fuel bed or to holes in the fire. The furnace draft also drops whenever the furnace doors are opened.

There is no practical method of firing, however, with which some nonuniformity in the fuel bed does not occur. When the doors are coaled in succession, part of the fire will be covered with fresh coal while the remainder is bright. This condition is considered more conducive to perfect combustion than if all doors were coaled at the same time, for in the former case the heat from the bright portion of the fire helps to raise to the ignition temperature the volatile matter distilled from the coal just thrown in the furnace. This method is also considered better than throwing the coal on the front part of the grate, allowing it to coke, and then pushing it back over the whole grate.

The coaling should be done as nearly uniformly as possible, throwing on the same number of shovelfuls each time. The firing intervals should be selected so that each charge will not exceed 30 to 50 pounds of coal (3 to 5 shovelfuls). Then the fireman can slightly increase or decrease the quantity as he finds his fires getting thinner or thicker. He will sometimes find the fire within one door consuming more coal than in the other doors. This condition can generally be traced to a thinner fire, which allows a larger quantity of air to pass through to intensify the combustion. If necessary the fire in that door should be kept a little thicker than in the other doors to equalize the rates of combustion.

If the coal is fired in small quantities at uniform intervals, and the fires are otherwise maintained in good condition, the smoke formed will have the minimum density for the boiler in use and the coal fired. The coal particles carried along by the gases are therefore cooled by the heating surface below the ignition temperature before they have time to burn completely. Smoke consequently forms. With high-volatile coals a dense black smoke is continually emitted from the stack, but with medium or low-volatile coals smoke should occur for a few seconds only after coaling.

Based upon the foregoing considerations, there has been adopted the following method of firing coal during evaporative tests at the Naval Engineering Experiment Station: The draft at the base of the stack is maintained constant at 0.750 in. water, for this stack draft has been found to burn about 25 lb. of coal per square foot of grate surface per hour, with a furnace draft of about 0.3 in. water. The boiler is allowed to generate as much steam as it can under a steam pressure of 300 lb. gage, which is kept constant by regulating a throttle valve on a bleeder line through which a portion of the steam generated is discharged to a surface condenser. A firing interval of five minutes has been selected, resulting in a charge of about 40 lb. of coal being fired at a time. The furnace has three doors, so that the interval between firing the successive doors is 1 min. 40 sec. The fires are leveled at 5-min. intervals, and in the order in which the doors are coaled: When door No. 1 is coaled, door No. 2 is leveled; when door No. 2 is coaled, door No. 3 is leveled; and when door No. 3 is coaled, door No. 1 is leveled. The slice bar is used at hourly intervals, but only if dark spots appear in the ash pan. The cleaning interval is twelve hours. With three furnace doors and firemen's watches of four hours on and eight hours off, the interval results in the cleaning of a fire each watch.

Samples of the flue gases from the base of the stack are collected during half-hourly intervals and immediately analyzed for CO_2, O_2 and CO. Analyses for hydrocarbons are made several times during each test, but no appreciable percentages have been found with coals tested to date. A CO_2 machine is also in continuous operation. The firemen are directed to so regulate the thickness of the fires as to maintain the constant percentage of CO_2 which yields the best results. This percentage has been found to be in general about 12 to 12.5 per cent., corresponding to a fuel-bed thickness of approximately 6 in. Leakage of air through the casing is prevented by carefully plastering before the test all possible cracks with asbestos cement.

The Cumberland Method of Preventing Corrosion*

The most widely held theory at the present day is that corrosion is due to galvanic or electrochemical action.

Thermo-electric couples also exist, due to variation of temperature. Evidence of this is found on the water side of furnaces in boilers [the author likely refers to internally fired boilers] along the line of fire-bars, and much of the deterioration of hot-water pipes in heating systems is due to electrolytic action between the hot and cold parts.

Galvanic action occurs between the harder and softer parts of the same metal. This is met with in parts of a structure which have been flanged, riveted, calked, hammered or stressed in any manner, either during manufacture or by reason of unequal working strains. The stressed parts are found to be electro-positive to the softer, or normal, parts.

It is well known that if two plates—one of zinc and the other of copper—are placed in a liquid, a difference of electrical potential exists, the zinc electro-positive to the copper; and also, that two pieces of the same metal—one having been strained or hammered, and the other in its normal state—being similarly immersed, show the former to be electro-positive to the unstressed part. Further, if we consider the surface of an alloy containing segregated parts of its different constituents, these parts have differences of electrical potential in proportion to the position of the constituents on the galvanic or electro-potential scale. When the liquid forms the conductor or electrolyte, the flow of electrical energy is from positive to negative, and the metal from which the current enters the liquid suffers electrochemical change in the form of corrosion. The reason corrosive action is more pronounced when metals are in contact with sea water is because this is a better electrolyte.

The extensive corrosive action which causes the failure of condenser tubes manufactured from an alloy of copper and zinc is principally attributed to this action and takes up various forms. In some instances it appears in the shape of minute holes through the tubes, and in others areas of various dimensions become weakened and ultimately develop cracks and break away. On examination it is noticed that the zinc had disappeared from the alloy, leaving the copper unsupported. This is generally termed "dezincification," and when it occurs locally, the life of the tube is short.

The corrosion of all ferrous and nonferrous structures may be lessened by connecting, in good electrical contact, a metal which is known to have a greater electrochemical affinity for acids and oxygen than the metal of which the structure consists. When this is done, the corrosive action is transferred from the structure to the auxiliary metal.

The best protective metal to use is pure rolled zinc. The zinc is only temporarily effective, the reason being that the surface of the protective metal soon becomes oxidized, and in consequence rapidly loses its power to protect; therefore it must be renewed at frequent intervals, otherwise it becomes heavily coated with oxides and reversal of polarity will soon occur. If the deteriorated zincs are not renewed frequently, the result will be accelerated corrosion of the structure instead of protection. There are many disadvantages associated with this method of protection. For instance, 1 sq.ft. of zinc, when new, will protect only about 50 sq.ft. of immersed structural surface. This means a large amount of zinc if one is contemplating the protection of the steam plant. And, added to this, every piece of zinc must be fitted in good metallic contact. The method of fitting these auxiliary plates of an electro-positive metal has been in vogue since the days of Sir Humphry Davy. There is no doubt that it is right in principle, but it fails to protect completely, and if not frequently renewed, causes detrimental reaction, as zinc scale has been tested and found to be electro-negative to many kinds of steel, iron, brass, Muntz metal, and Admiralty mixture for condenser-tubes.

After investigating numerous acute cases of corrosion and noting the various attempted remedies, it was obvious to the writer that the complete protection of all metals immersed in liquids was a simple matter, comparatively inexpensive and within the reach of all. The apparatus consists of a low-tension dynamo generating continuous current at a pressure of 6 to 10 volts, and pieces of iron suspended in the water contained in the vessel to be protected and suitably insulated from it.

Fig. 1 shows the Cumberland process fitted to a surface condenser of the usual type, with the circulating water passing through the tubes. The iron anodes A are supported by the steel studs and insulated from the condenser door; these electrodes are connected through the adjustable resistance C and two-way switches D, Fig. 1, to the positive terminal of the generator.

The condenser itself is connected, as shown, to the negative terminal. An amperemeter E is fitted on the switchboard, and the supply of current to the electrodes can be regulated with the aid of the resistance coils C.

The common cause of failure of condenser tubes is galvanic action brought about in various ways, such as dissimilar metals in juxtaposition, the presence of carbonaceous matter in contact with the tubes, or difference of electrical potential, due to variations of temperature, etc. This action is neutralized by introducing a superior electromotive force from an external source, which overcomes the minor destructive currents due to these adverse conditions, insuring that the flow of current is always from the inserted electrode through the liquid on to the surfaces to be preserved.

Fig. 3 shows how the system is applied to a Scotch marine boiler. The iron anodes A are supported by insulated brackets fixed to the main stays in the steam space and extend between the tube nests, the immersed parts being kept clear of the internal parts of the boiler. They are connected through the insulated bolts B to the positive side of the circuit, and the exterior of the boiler at D is connected to the negative side. The current flows from the positive terminal of the dynamo to these electrodes, passes through the water and returns thence to the negative terminal. The immersed parts of the anodes deteriorate, and these are made easily detachable for the purpose of renewing. Their life under usual conditions is about two years, and they are made from ordinary bar iron and mild steel.

In regard to the amount of current required to protect surface condensers, this varies slightly, but in extreme cases 1

*Read by Elliott Cumberland before the Institute of Metals.

amp. per 500 sq.ft. is found in practice to afford complete protection. The anodes A, Fig. 1, fitted in a surface condenser, consist of cast-iron blocks 7 in. diameter, 2 in. thick, each weighing 20 lb. Take, for instance, a condenser containing 6,000 sq.ft. of cooling surface, the number of electrodes fitted would be six—three at each end—having a total weight of 120 lb. The amount of current supplied would be 2 amp. per electrode, giving a total of 12 amp. at 6 volts to protect the whole 6,000 ft. of cooling surface.

In boilers, where removal of scale has to be taken into account, the amount of current found necessary is more. For a single-ended Scotch marine type of boiler, 13 ft. 6 in. diameter and 11 ft. long, with a heating surface, of 2,700 sq.ft., from 9 to 10 amp. would be sufficient; this is on the basis of 1 amp. to 300 sq.ft. In an installation of twelve Yarrow water-tube boilers the total heating surface was 49,500 sq.ft.—equal to 4,125 sq.ft. per boiler. On the basis of 1 amp. per 300 sq.ft., 14 amp. per boiler was decided upon. The engineers on the ship found that this amount could be considerably reduced and all corrosion eliminated and heating surfaces kept clear of scale by using only 5 amp. per boiler; this works out at about 1 amp. per 800 sq.ft. of heating surface. The anodes consisted of two 7-ft. lengths of 3-in. by ¾-in. bar-iron, fitted in the steam drums slightly below the water level.

The writer has had the satisfaction of overcoming the most obstinate cases of corrosion when many other methods had been tried without success, and while effecting this, discovered that the regular working of this system had a most remarkable effect in decomposing and removing hard scale from the heating surface of boilers, etc., and also prevented further formation. This phase of the subject is of great importance to engineers when considering fuel efficiency.

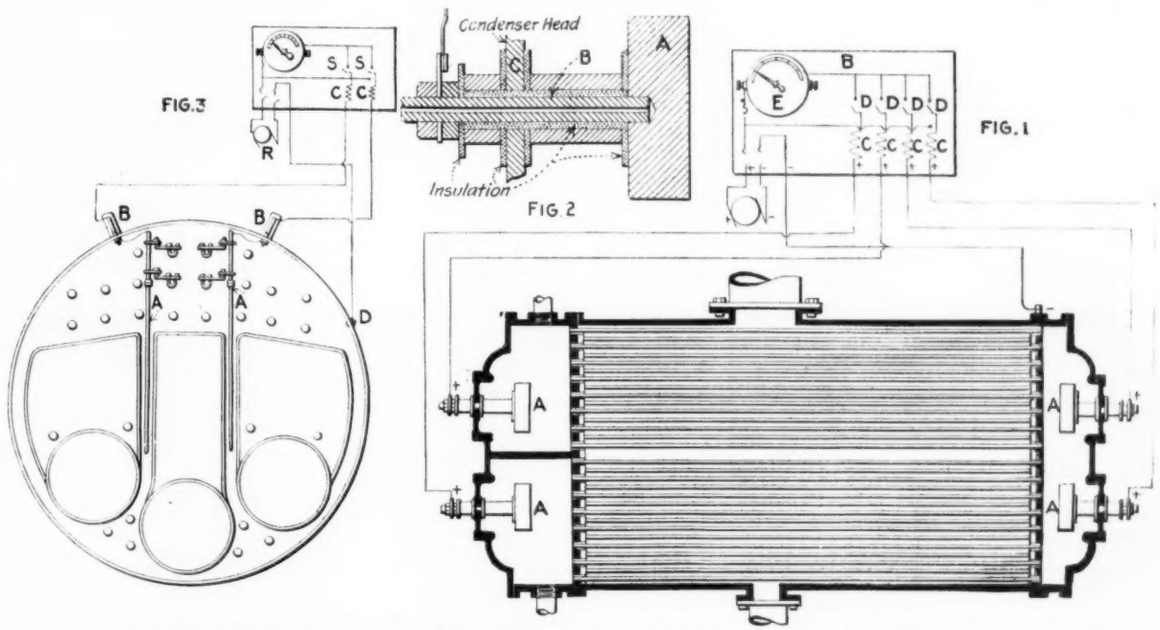
To deal in a simple way with the reason of nonformation of scale under the influence of this electrolytic process, it is necessary to remember that acids, bases and salts may each be regarded as being composed of two parts—a positive radicle and a negative radicle. Positive radicles are so called because they can, under certain circumstances, unite with and carry charges of positive electricity. Negative radicles, in a similar way, can unite with and carry charges of negative electricity. The following list shows how various substances arrange themselves under the influence of the current:

At the Anode Negative Radicles	At the Cathode Positive Radicles
Chloride	Hydrogen
Bromide	Sodium
Hydro-sulphide	Potassium
Nitrate	Ammonium
Chlorate	Calcium
Sulphate	Magnesium
Sulphide	Zinc
Oxide	Copper
Carbonate	Lead
Iodide	Iron

It is seen that hydrogen and sodium ions, among other positive radicles, seek the cathode and are liberated at the surface of the structure being protected; while the negative radicles—oxygen, chlorine—are directed to the anode.

On glancing down the list, it will be observed that the component parts of calcium sulphate and calcium carbonate are separated and cannot therefore combine at the heating surfaces and bake on in the form of scale. In fact, some of the insoluble elements which originally formed scale can be blown out of the boiler in a finely divided state. In dealing with old hard scale, a certain amount of decomposition takes place and it is rendered soft and spongy. The hydrogen forming on the metal underneath the scale loosens this, mechanically causing it to fall off. Further deposit of grease or foreign matter is prevented from adhering to the surface of the metal by this protecting film of hydrogen. The Cumberland process has removed hard scale of considerable thickness from the heating surfaces of boilers and made it possible for the boilers to be kept in continuous use for a period of nine months, where previously it was necessary to have them cleaned out every three weeks.

It may here be asked why, if hydrogen acts in this way, the liberation of steam does not prevent scale formation? It certainly does remove loose parts, and if solid substances were laid on the surfaces, it is probable that the steam bubbles would push them away. But when scale is formed on heating surfaces, a chemical action takes place, due to high temperature assisting certain elements to combine, and the evolution of steam does not prevent this combination.



FIGS. 1 TO 3. APPLICATIONS OF THE CUMBERLAND ELECTRIC CORROSION PREVENTION SYSTEM

Fig. 1—As applied to a surface condenser. Fig. 2—Section of one of the terminals. Fig. 3—As used for steam boilers

Another interesting phenomenon came under observation in the following manner: An ammonia condenser was used in a large ice factory; it contained numerous iron tubes through which sea water was circulated. These had suffered from severe corrosion, and the circulation of the water was retarded by growth of shellfish on the tube plate and ends of tubes, thus considerably reducing the efficiency of the condenser. After the Cumberland method had been put into operation, not only did the corrosion cease, but the shellfish and barnacles were also removed. The explanation of this is that hydrogen and sodium ions had been liberated on the protected surfaces, and this proved fatal to these marine organisms. The advantages of such a simple and inexpensive method of protecting all metals in contact with, or immersed in, water or other corrosive liquids, are obvious to those who study efficient maintenance.

The Cumberland system is being tried by the British Admiralty in boilers.

Dripping from Cold Water Pipes caused by the condensation of moist air upon their surface may be prevented by wrapping the pipes tightly with several thicknesses of paper, and it will prevent rust from attacking the outer surface of the pipe.

Detroit Meeting of Heating and Ventilating Engineers

On July 19-21 the American Society of Heating and Ventilating Engineers held its semiannual meeting at the Hotel Statler, Detroit. The newly formed Michigan Chapter is to be congratulated on the success of its first efforts in conducting a national convention. The attendance was unusually large, the papers interesting and the entertainment fully up to the Detroit standard. In behalf of Mayor Marx, Mr. Lee, of the corporation council's office, welcomed the conventioners. H. M. Hart, president of the society responded. Briefly he reviewed past and future plans and particularly mentioned the recent large increase in membership, which had been due largely to the formation of the new chapters. In 1914 the increase was 75, in the following year 110, and in the first half of 1916 the net gain in membership was 109. Chapter reports reviewing the work done in the past year and reports from special committees followed. John F. Hale reported the gathering on engineering coöperation held in Chicago last April and recommended that the society be represented on the committee working toward this end and to a reasonable degree help defray the expenses. It was the sense of the meeting that the matter be referred to the council for favorable consideration.

The committee appointed to determine the best position for a radiator in a room gave the results from 22 tests with the radiator in ten different positions. It was found that the most steam was condensed with the radiator on the floor in the center of the room, a little less when the radiator was placed on the inside wall, and there was a further drop in efficiency with the radiator in the usual position parallel to the wall and under the exposed glass surface. The discussion brought out the efficiency of the radiator, rather than uniformity of temperature in the room or avoidance of draft, was the point at issue.

At the afternoon session, Wednesday, James A. Donnelly presented an interesting paper on the "Design of Fractional Valves." The adaptability of the various types of fractional valves to gravity and vacuum return-line systems was discussed, and data giving areas of orifice necessary with different pressure drops were presented. The author suggested a new form of dial for these valves. In the paper the range in square feet of radiation was given for different sizes of valves. In the discussion it was pointed out that if the valve was designed for the lower limit, it would not be satisfactory at the higher, so that special control was needed. Disks were not favored as the steam fitter rarely inserted them properly. The opinion was expressed that the manufacturer supplied larger valves than necessary. Experience with a radiator on a vacuum modulation system showed that a valve of one-half the usual diameter filled the radiator with steam. Quick action was the explanation offered for the larger valve, with a trap at the other end of the radiator to prevent waste of steam. It was pointed out that the size of the valve was determined by the drop in pressure through it rather than by the amount of steam it would pass.

"Clean Pure Air for Our Cities" was the title of the next paper, which dealt particularly with the removal of cinders and dust from the products of combustion emitted from a power-plant chimney. The device described consisted mainly of a large settling chamber fitted with a set of baffles and collection hoppers at the bottom. The use of wet surfaces, both stationary and revolving, to remove the soot and dust from the smoke was given attention in the discussion. The Lake Shore roundhouse installation in Chicago, where the smoke is passed through water into which large quantities of steam are injected, was cited, and W. J. Baldwin gave a special demonstration of a motor-driven fan separator which he had invented for the purpose. A vertical baffle projecting downward from the top of the breeching opening into the stack had resulted in throwing down large quantities of soot. Papers on commercial drying apparatus and on the ventilation of garages completed the session.

On Thursday the sessions were held at Ann Arbor in the Engineering Building of the University of Michigan. Prof. John R. Allen presented a valuable paper on "Heat Transmission Through Building Materials." Results from a series of experiments with window glass were given. The special testing box used, the equipment devised for producing effects of rain and wind and the method of supplying heat to the box were described. Tests were run with glass exposure in different positions and under four typical conditions of weather—quiet, rain, wind, and wind and rain. Under the condition last named, that is with wind and rain, the experiments showed that the coefficient for glass should be 1.48, or approximately 1.5. This figure, in the opinion of the author, would more nearly represent the maximum loss from glass than the coefficient 1, which is used at the present time. The University of Michigan expects to carry on this line of experiments for a series of years, taking up plate glass, different thicknesses of cement and other forms of building material. The discussion turned to the effect of humidity, temperature and the sun on the coefficient of transmission, the effect of the different positions of the glass and the separation of the heat passing through the glass by radiation and convection.

HEATING AND VENTILATING ENGINEERS AT DETROIT, MICH.

In his paper on the testing of warm-air furnaces, R. W. Davenport had found that the "standard" method was impossible, owing to the enormous error in judging the heat stored at starting and stopping. The alternate method had been used with success on runs of 18 hours or more, but proved unreliable on shorter runs. To eliminate this uncertainty the so-called "balance" method was devised. The author described this and pointed out the significance of the results obtained.

The last paper of the day, on "Coefficient of Friction of Air Flowing in Round Galvanized-Iron Ducts," was read by Prof. J. E. Emswiler. Tests made on 6- and 12-in. sizes showed that the coefficient of friction rises rapidly with lower velocities of flow and that the coefficient is higher for the first section of pipe beyond the blower than for the second. The value of 0.006 generally used in computations is a good average value, but, according to the data obtained, is correct for only one velocity. Near the fan the air flows with more disturbance and interference. Here the center velocity of the air

in the pipe is not much different from the average velocity. More distant from the fan the center velocity is much higher than the average, indicating that more air is passing through the center of the pipe, thus coming less in contact with the confining surfaces and causing less friction. The experiments will be continued under a wide range of conditions, embracing different materials, cross-sectional shapes and obstructions of various kinds.

"Engineering and Cost Data Relative to the Installation of Steam Distributing Systems in a Large City," by F. H. Valentine, was the first paper Friday morning. It was devoted to the location, cost and general design of underground steam mains, including calculations of sizes and discussion of materials and fittings. Methods of insulating the mains, their drainage, opening up pavements, trenching and the entire problem of estimating the amounts of material and costs were included. A valuable feature was the presentation of a typical problem indicating the method of procedure in estimating. The discussion touched upon foundations to carry the pipe lines, the basis of labor costs in laying the pipe and the overhead costs on the work.

A paper by J. D. Hoffman, on "Heating a Conservatory and Greenhouse," described a successful installation of hot-water heating involving the extension of an older plant and also provisions for future extension. The heating system was of the hot-water open-tank type with the radiators and coils all connected on the downward-flow principle. The old conservatory rooms were badly cut up and the connections complicated, but the system gave good satisfaction. A complete analysis of the new installation was given in the paper.

C. W. Obert, secretary of the society, read the last paper presented at the convention. The subject was the "Effect of the A. S. M. E. Boiler Code on Heating Boilers." The Code committee's work was reviewed and the advantages to the trade and the user were enumerated. It was brought out that a separate section of the rules covering the heating section had been provided and that the rules had been adjusted so as to establish a line of demarcation between the power and heating classes of boiler. This arrangement gave ample opportunity for adequate treatment of the special conditions embraced in heating boilers. It was specifically stated that no rules had been imposed that would be likely to impose a hardship or work to the disadvantage of any manufacturer who was prepared to build a safe boiler. To avoid criticism from the general public, no rules were imposed on old boilers or on boilers that were now in use. In the discussion some objection was made to the 15-lb. limit placed by the code on low-pressure boilers. Safety did not demand it, and in some cases it worked a hardship. On hot-water boilers 30 lb. was allowed. It was made clear that the limit had been carefully considered not only from the standpoint of safety, but from the legal aspect as well. It was the demarcation between boilers that must be inspected and those that did not require it. In any event there was always the opportunity to present a grievance to the committee and the possibility of an exception being made.

J. C. McCabe, chief boiler inspector of Detroit, emphasized the necessity of a uniform code. The A. S. M. E. Code was good and it would be adopted soon in Detroit. All regulations to be successfully applied must be construed on a reasonable basis. Education rather than enforcement was the better method. The Code under discussion was reasonable. Some sacrifices must be made, and the engineer should regard it from an engineering basis rather than from his own particular viewpoint. A short discussion on the rating of low-pressure cast-iron boilers followed, and the meeting adjourned, leaving the afternoon free for visits to industrial plants in the city.

NEW PUBLICATIONS

HOME STUDY COURSE IN PRACTICAL ELECTRICITY. By W. H. Radcliffe. Published by the McGraw-Hill Book Co., Inc., New York and London, 1916. Cloth; 6x8½ in.; three volumes; 749 pages; 454 illustrations. Price, $6 net.

The material in these volumes was originally prepared by the author and published in "Power" under the title of "The Electrical Catechism," during a period extending from Jan. 1, 1905, to July 16, 1912. A widespread interest was taken in these articles at that time. The original material has been rewritten, revised and brought up to date. In doing this great care has been exercised to simplify the descriptions and explanations so as to bring the subject matter together in a harmonious whole. In the present volumes there are 1,400 questions and answers given in such a form as to provide a simple course in electricity and magnetism.

The work begins with the fundamental principles of electricity, electrical units, conductors and insulators, the calculation of resistance and electric circuits. The subject of storage batteries is treated in 58 pages; after which 95 pages are devoted to magnetism, electromagnetic induction and direct-current generators. The remaining 58 pages of the first volume deal with alternating current and alternating-current generators. The second volume opens with 26 pages on transformers, followed by 93 pages dealing with the subject of electrical measurements and instruments. The last 105 pages of this volume are on switchboards, switchboard wiring and operation and station wiring. The first 105 pages of the third volume deal with direct-current motors, alternating-current motors, motor generators, dynamotors and rotary converters, followed by 50 pages on incandescent and arc lamps. The last part of this volume deals with substations and the management of electrical stations. The illustrations form a very important part of the work, being 454 in number and of such a character as to give a wealth of detail about the subjects treated. These volumes should find a large field of usefulness among those who have not had an opportunity to obtain the proper electrical training and who desire to acquire a better knowledge of the fundamental principles of electricity and magnetism and electrical machinery.

MECHANICAL DRAFTING—By Charles B. Howe. John Wiley & Sons, New York City. Cloth; 8¼x11 in.; 147 pages; 166 illustrations. Indexed. Price, $1.75.

Reviewed by A. L. Ormay*

The noteworthy features are thoroughness and the practical exclusion of all nonessentials to the subject of mechanical drawing. The book forms an excellent manual for teachers, in that it supplies all the conventions and problem sheets likely to be found necessary in any course. The treatment of orthographic projection is spendidly conceived and thoroughly worked out.

In the chapter on the principles of drafting, all the operations necessary in the execution of any drawing are clearly set forth and explained. The two chapters on geometry of drawing, primarily devoted to orthographic projection, the intersection of surfaces and the development of surfaces, are simply and comprehensively worked up. A marring feature here, as well as throughout the volume, is that the wax illustrations not only present a somewhat stiff appearance, but in some instances account for misplaced shade lines and still further produce a rather amateurish effect in the surface shading.

The chapter on working drawings is essentially complete, from the manual point of view, while the chapter on machine drawing contains all the conventional screw threads, bolts and stock parts, with a number of excellent examples showing the method of dimensioning the layout of holes, ordinary and standard tapers, shafts, long screws, etc.

Individually, the chapters on plan drawing and plot and map drawing are calculated to be of value, although the elaborate treatment of architectural drafting is slightly afield in a manual on mechanical drawing. Likewise, the chapter on plot and map drawing—well written but poorly illustrated—is scarcely well classified.

In the chapter on pictorial representation and sketching the construction of isometric, perspective and cabinet drawings is taken up and the rules formulated for making working sketches.

The book as a whole reflects a conscientious effort to make the treatment comprehensive, lucid and simple and conspicuously avoids the crowding in of minor details. Especially commendable features are the elegance of the typography, the arrangement of the cuts and the pleasing effect obtained by the use of an unusually good quality of paper.

INDUSTRIAL LEADERSHIP—By H. L. Gantt. Yale University Press, New Haven, Conn. Cloth; 5x7⅞ in.; 128 pages; 9 charts. Price, $1.

The five chapters of this book constitute the Page lectures for 1915, delivered before the senior class of the Sheffield Scientific School, Yale University. Presented now in permanent form, this book is one of the most important of recent works dealing with any phase of industrial management.

In some quarters there is a feeling of uneasiness and dread of the coming period of industrial competition that must follow the great European War. Mr. Gantt in his foreword admits that autocracy in the past has been able to organize a nation for both industrial and military efficiency in a manner superior to anything that has been accomplished by democracy. He then goes on to say: "If democracy is to compete successfully with autocracy in the long run, it must develop organizing and executive methods which shall be at least equal to those of the autocracy." He believes that this

*Chief draftsman, Hill Publishing Co.

can be done, however, and states the purpose of his lectures as follows: "In this course of lectures I have tried to set forth the principles on which I believe an industrial democracy can be based which will be even more effective than any system of industrialism which can be developed under autocracy."

The titles of the five lectures, or chapters, are: Industrial Leadership; Training Workmen; Principles of Task Work; Results of Task Work; Production and Sales.

Every man who wishes to keep in touch with the newer theories and developments of the best thought on industrial management should read this book.

PERSONALS

Hugh L. Thompson has accepted a position with the A. S. Cameron Steam Pump Works, St. Louis, Mo.

Arthur S. Hawks is now assistant chief engineer of the Busch-Sulzer Bros. Diesel Engine Co., of St. Louis, Mo.

Franklin W. Gilman, formerly with the Sanford Riley Stoker Co., Ltd., at Worcester, Mass., is now associated with the B. F. Sturtevant Co., at Chicago, Ill.

Perry R. Cassidy, formerly assistant professor of thermodynamics at the University of Kentucky, Lexington, is now with the Babcock & Wilcox Co., at Barberton, Ohio.

E. J. Burdick, for many years superintendent of power stations for the Detroit (Mich.) United Railways, has been appointed assistant general manager of the company.

Max F. C. Pawlik, formerly engineer of the Consolidated Gas, Electric Light and Power Co., at Baltimore, Md., is now marine engineer with the Panama Canal at Paraiso, C. Z.

Frederick R. Pratt, formerly master mechanic and chief engineer of the Berkshire Cotton Manufacturing Co., Adams, Mass., is now mechanical engineer of Bird & Sons, of East Walpole, Mass.

Earl W. Fry, for sixteen years employed as electrician by the Howard Gas Coal Co., at Greensburg, Penn., is now in the experimental department of the Westinghouse Air Brake Co., at Wilmerding, Penn.

Henry O. Pond, formerly mechanical engineer of Westinghouse Church Kerr & Co., is now in charge of the timber, pulp and water-power interests in the Northwest of E. B. Cadwell & Co., Inc., with offices at 25 Broad St., New York.

Lester G. French, editor of the "Journal" of the American Society of Mechanical Engineers, who recently underwent a serious operation at the French Hospital, New York, is now convalescent and expects to be about again shortly.

Sterling H. Bunnell, for many years chief engineer and sales manager of the Griscom-Russell Co., New York, has become chief engineer of R. Martens & Co., Inc., the New York connection of R. Martens & Co., Ltd., of London, England.

Walter P. Alexander has resigned as engineer and works manager of the Providence Engineering Works, Providence, R. I., to become steam and mechanical engineer of the Moulton Engineering Corporation, consulting engineers, of Portland, Maine.

R. L. Daugherty, formerly assistant professor of hydraulics at Sibley College, Cornell University, is now professor of hydraulic engineering at Rensselaer Polytechnic Institute, succeeding Prof. Lewis F. Moody, who has resigned to enter private practice.

W. H. Kavanaugh, who for 15 years has been a member of the faculty of the College of Engineering at the University of Minnesota, has accepted the professorship of experimental engineering in the Towne Scientific School of the University of Pennsylvania, at Philadelphia, to take up work there on Sept. 1.

Stevenson Association No. 44, N. A. S. E., will hold its eighteenth annual outing and games on Sunday, Aug. 6, at Midland Park, Grant City, Staten Island. The executive committee, under the guidance of Harry Langham, has spared no effort to make this outing the biggest of 44's proverbial successes. Those attending are assured of a splendid entertainment. Tickets are $2 per person (children 50c.) and may be obtained either from the secretary of the outing committee, T. J. Condon, 676 Hudson St.; the individual members or at the gate.

OBITUARY

CHARLES KIRCHHOFF

Charles Kirchhoff, a noted mining engineer, of 587 Riverside Drive, New York City, and for 20 years editor of "Iron Age," died on Saturday, July 22, at his summer home, "Wanamassa," Asbury Park, N. J., at the age of 64 years.

Mr. Kirchhoff was born in San Francisco, Calif., and was educated in this country and in Germany, graduating with the degrees of mining engineer and metallurgist from the Royal School of Mines at Clausthal, Germany, in 1874. Returning to this country, he was for three years chemist, assistant superintendent and assayer for the Delaware Lead Mills at Philadelphia.

In 1876 he began his career in technical journalism during the Centennial Exposition by acting as correspondent for the English, German and Capetown (Africa) papers. He became connected with the "Metallurgist Review" in 1877 and later joined the staff of "Iron Age." In 1880 he became the managing editor of "Engineering and Mining Journal," returning to the staff of "Iron Age" in 1884. Four years later he became editor-in-chief of the latter periodical and vice-president of the David Williams Co., its publishers, from which positions he resigned in 1909.

Mr. Kirchhoff was at one time a special agent of the United States Geological Survey. He was president of the American Institute of Mining Engineers in 1898-99 and 1911-12, a member of the American Society of Mechanical Engineers, the Iron and Steel Institute, the Verein Deutscher Eisenhüttenleute, the Century and Engineers' Clubs of New York City, once president of the Germania Club and an honorary member of the Franklin Institute of Philadelphia.

SIR WILLIAM RAMSAY

Sir William Ramsay, an eminent chemist, died Sunday, July 23, at his home "Beechcroft," at Hazlemere, Buckinghamshire, England.

Sir William Ramsay was born in Glasgow on Oct. 2, 1852, and was educated in Glasgow Academy and University. In 1894, in collaboration with Lord Rayleigh, he discovered a new gas, argon, the third constituent element of the atmosphere. This, his greatest achievement, brought him worldwide fame. In 1903, when he was professor of chemistry at the University College, Bristol, he announced the existence of three new gases, neon, krypton and xenon. The announcement by Johns Hopkins University in 1907 that Sir William had discovered the possibility of the transmutation of one element into another startled the chemists of the world. The results of his experiments along this line have not as yet been announced.

He has received many honors, perhaps the greatest being the Nobel Prize in Chemistry, which was awarded him in 1904. He was created a knight in 1902.

BUSINESS ITEMS

The Sanford Riley Stoker Co., Ltd., of Worcester, Mass., has moved its main office from 72 Commercial St., into larger headquarters at 25 Foster St.

The Murray Iron Works Co., Burlington, Iowa, builders of boilers and engines, have arranged for a New York sales office at 39-41 Cortlandt St. The office is in charge of Paul Bigelow.

The Interborough Rapid Transit Co. has recently ordered nine 4,000-kw. synchronous converters from the General Electric Co. for service in New York City. This makes a total of 19 of these machines, having an aggregate capacity of 76,000 kw., to be used on the Interborough lines.

The Merriam Co., located for some time at 235 Superior Ave., N. W., Cleveland, Ohio, has just moved into new quarters at 1514 Prospect Ave., Cleveland. The business of this company has been growing very steadily and in the large new location they are in position to give their customers most excellent service and attention.

Classified Ads

appear on pages 140 and 141 of this issue and will in future appear in the same relative position in the paper. Page numbers will be given in the Table of Contents under the heading "Special Opportunities Section."